City of Norfolk, Virginia
Department of Utilities

Sewershed Investigation Guidance Manual

September 2004

City of Norfolk, Virginia
Department of Utilities

Sewershed Investigation Guidance Manual

Table of Contents

Section Page Number

Table of Contents
(continued)

Section | Page Number

Table of Contents
(continued)

Section Page Number

Table of Contents

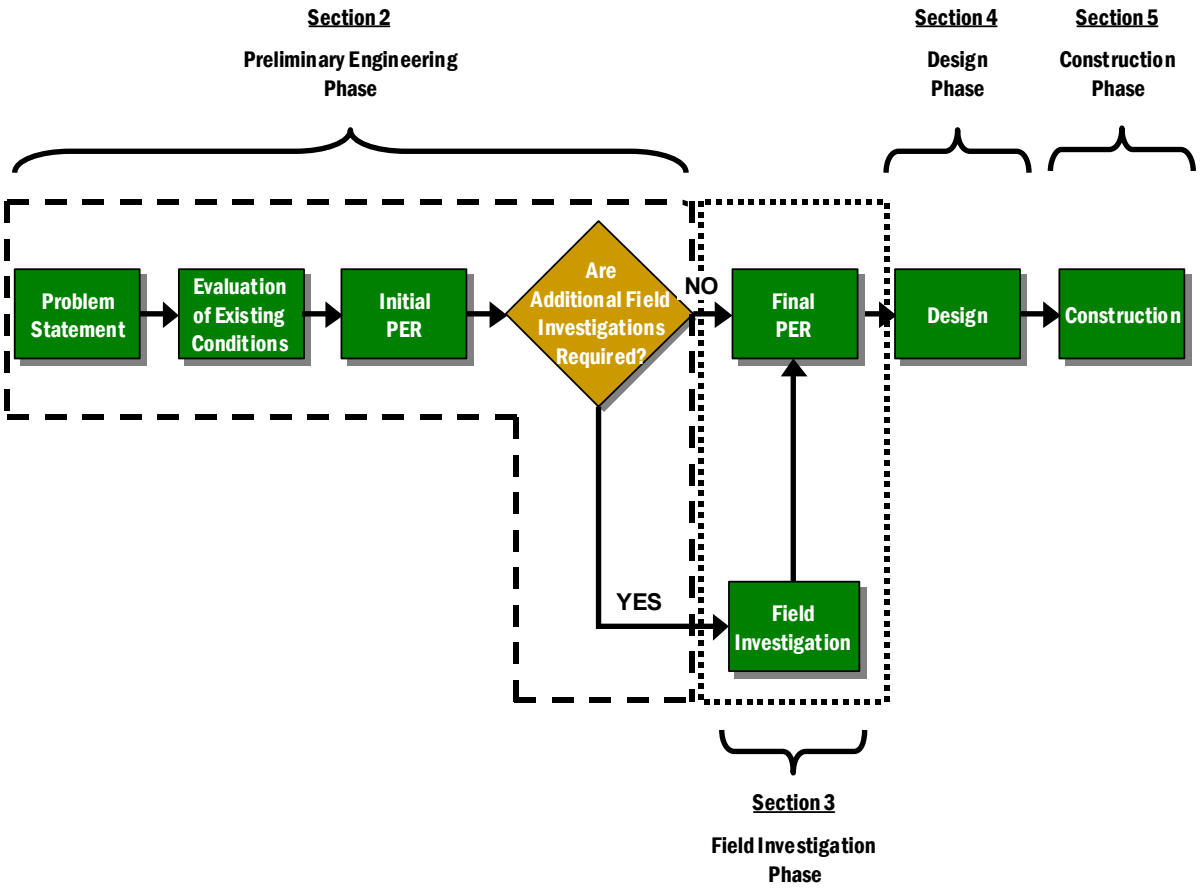
(continued)

List of Tables

List of Figures

List of Appendices

Figure 1-1
Sewershed Investigation Flow Chart



SECTION 1
INTRODUCTION

1.1 BACKGROUND

The Norfolk Sanitary Sewer Collection System (System) is one of the oldest in the nation and includes sewers that were installed as long ago as 1913. As of 2004, the System assets include 867 miles of sewer lines and 152 pumping stations, with 127 owned by the City and 25 owned by the Hampton Roads Sanitation District (HRSD). The System comprises an area of 52.4 square miles and serves approximately 55,000 residential and 12,000 non-residential structures. Ultimately, all wastewater generated in Norfolk is transferred for conveyance and treatment to facilities owned and operated by HRSD.

In order to develop a comprehensive long-range plan for the upgrade of its System, the City of Norfolk (City) embarked on a Sanitary Sewer Evaluation Survey (SSES) in July of 2001. Subsequently, the City, the State Water Control Board (Board), and HRSD agreed to a Special Order by Consent (Order), which became effective on December 17, 2001. The City's SSES report was incorporated into the Order, which stated its purpose as follows:

> "***The purpose of the SSES is to document the existing system layout and load capacities, identify areas requiring rehabilitation, improvements, and/or maintenance, and propose recommendations for rehabilitation and infiltration and inflow reduction."***

In compliance with the Order, the SSES Report was submitted to the Virginia Department of Environmental Quality (DEQ) on July 31, 2003. The SSES Report received approval from DEQ on December 12, 2003.

In order to control sanitary sewer overflows (SSOs), the City's SSES presents recommendations to address capital projects for SSO control as well as System management, operation and maintenance (MOM) practices. Recommendations for System upgrades are classified into two main categories as follows:

- **SSO Control Projects.** These capital SSO Control Projects will provide remediation of the various conditions that have been identified as causing SSOs within the System. The SSO Control Projects are organized into a Long-Term Control Plan (LTCP) that has an implementation schedule of 15 years.
- **System Assets Upkeep Projects.** These are capital projects associated with the normal upkeep of the System assets and reliability of service. The System Assets Upkeep Projects, not included in the LTCP, are performed through the City of Norfolk's Department of Utilities (Utilities) ongoing Asset Upkeep Program. The System assets upkeep projects will continue to modernize the System and preserve its long-term integrity.

Through implementation of the SSES recommendations (both LTCP and Asset Upkeep), it is estimated that by the year 2035, the age and condition of all the System assets will be equivalent to those of a system less than 50 years old.

As a System wide study, **the SSES focused on the relative condition of the sewersheds** and the corresponding prioritization of the work within the entire System. One of the SSES's major objectives was to estimate levels of remediation required for each sewershed. A general assessment was made of the System's existing conditions by compiling and evaluating data from such sources as the City's information management system, field investigations, hydraulic modeling and engineering and financial evaluations. Field investigations were conducted to the extent needed to obtain a representative sampling of the System conditions. The representative system condition sample was used to estimate conditions in all of the City's sewersheds, based on similar sewer ages and materials. The SSES recommendations included an implementation plan and schedule, with the sewershed prioritization based on a relative ranking of criteria such as SSO control, Infiltration and Inflow (I/I) reduction potential, total and incremental rehabilitation costs, and asset conditions.

Accordingly and subsequent to completion of the SSES, **the focus and intent of the individual sewershed investigation projects is to provide a detailed evaluation of the specific needs within a particular sewershed** and to provide cost effective rehabilitation recommendations consistent with the SSES program and City guidance.

1.2 PURPOSE, OBJECTIVES AND USE OF THIS MANUAL

This Sewershed Investigation Guidance Manual (Manual) has been developed to promote **consistency and uniformity** in conducting sewershed evaluations and designs of collection system improvements within the City. The City may perform the services described in this manual using a team comprised of Utilities' staff, consulting engineers or a combination of both. In this manual the term "Engineer" refers to the team assigned by the City for any given project. This Manual also defines general responsibilities of the Engineer during design and construction of recommended projects.

This Manual is not intended as a regulation, but is intended to be used as a guide that will provide consistency to the preliminary engineering, field investigation, final design and review of wastewater utility improvements that are owned by the City and maintained by Utilities. As it is difficult to generalize engineering design matters, Engineers and developers should evaluate projects using the information presented herein as a guide. This guidance document is not intended to replace sound engineering judgment. Engineers should consider the applicability of the contents of this document to the City's capital program projects and, based on the characteristics and requirements of the specific projects, make adjustments accordingly.

This Manual is intended to be used in conjunction with the current editions in use by the City of each of the following: the City of Norfolk Standard Design Criteria Manual; all applicable building, plumbing, and electrical codes; the Hampton Roads Planning District Commission (HRPDC) Regional Standards as amended and modified by Utilities; the Virginia Department of Transportation Road and Bridge Specifications; the Virginia Department of Environmental Quality Sewerage Collection and Treatment (SCAT) Regulations and the Department of Public Works Right-of-Way Excavation and Restoration Manual. Users of this guide should recognize the fact that all local, state and federal codes and regulations must be satisfied on all projects. In the event that these Standards differ from state or federal requirements, the more stringent standard shall apply.

Information in this manual incorporates engineering assumptions and practices used and acknowledged by Utilities, including a compilation of widely accepted field investigation techniques, design practices and standards currently in use throughout the professional engineering and wastewater communities. **Deviations from this guidance manual, such as special or unique engineering situations, should be substantiated and thoroughly addressed in the Preliminary Engineering Report (PER).**

1.3 APPROACH FOR SEWERSHED INVESTIGATIONS

The City's approach for sewershed investigations, and thus the development of this Manual, involves four major phases of engineering services for Engineers. These work phases, and their associated location in this Manual, are as follows:

- *Preliminary Engineering Phase* – Section 2
- *Field Investigations Phase* – Section 3
- *Design Phase* – Section 4
- *Construction Phase* – Section 5

A schematic flow chart of the sewershed investigation process is provided as Figure 1-1, which shows an overview of the process described below and which serves as a guide for information provided in this Manual.

Figure 1-1
Sewershed Investigation Flow Chart

(Located at the beginning of this section)

The initial phase of the sewershed investigation work, generally referred to as the ***Preliminary Engineering Phase*** (Section 2) will include the following:

- Problem Statement
- Evaluation of Existing Conditions
- Preliminary Engineering Report

A general description of each element of this phase follows:

- *Problem Statement* – The problem statement represents the City's current understanding of the major issues and problems that have resulted in pursuing additional detailed investigations in a given sewershed. This statement helps to define the City's needs and objectives for each specific sewershed investigation, is incorporated into the City's Request for Proposal, and is based on the SSES program development and experiences of the City's operations and maintenance (O&M) staff. Typically, objectives of the specific sewershed investigations will include the need to control SSOs, reduce I/I, address maintenance and operational needs, and systematically upgrade the sewer assets (a reduction of the equivalent age of the sewer system assets).
- *Evaluation of Existing Conditions* – This phase involves compiling and reviewing existing data and conducting a preliminary condition assessment of the gravity sewers, pumping station and force main(s) in the sewershed. Included are such tasks as: project and agency coordination; review of the SSES and other existing reports; review of the SSO control and I/I reduction objectives; review of current O&M practices; meeting with the City O&M, Data Management and Engineering staff and performing field reconnaissance as appropriate.
- *Preliminary Engineering Report* – Upon completion of the Evaluation of Existing Conditions, the Engineer is to prepare an Initial PER to document the sewershed evaluation including findings, recommendations and a cost effective analysis of alternatives for the rehabilitation of the sewershed.

Detailed sewershed evaluations are to be conducted for both present and future conditions. A key element of the evaluation phase of the PER is the confirmation of the SSO control objectives of the SSES program and refinements of the I/I reduction goals provided in the Problem Statement.

Included in the Initial PER will be a determination by the Engineer that either:

1. Additional Field Investigations are required - in this case the Engineer should proceed with the Field Investigations phase of the project after authorization by the City and subsequently produce a Final PER, or
2. No additional Field Investigations are required - in this case, the Engineer should proceed directly to a Final PER.

This report is to be submitted to Utilities (and in some instances the DEQ) in the form of a PER with a standardized format and outline as presented in this Manual.

The next phase of services is referred to as the ***Field Investigation Phase*** *(Section 3)*. This section of the Manual is organized as follows:

- *General Approach* – The different types of field investigations are introduced. A general matrix is presented to initially evaluate the types of field investigations that may be most appropriate based on the issues involved and the type of system element investigated. Also, a phased approach for the cost effective use of field investigations is presented.
- *Gravity System* – Included are protocols for field investigations such as manhole inspections, smoke and dye testing and CCTV work. Also included are discussions about integration of the field data with the City's data management system.
- *Pumping Stations and Force Mains* – Provides information on pumping station inspections, including standard forms for recording such field information. Guidance is also provided on general assessment of force mains.
- *Other Field Investigations* –Considerations for flow monitoring and surveying are presented in this section. Also included is guidance on the use of this information in preparing the final PER.

The ***Design Phase*** (Section 4) includes discussion on the submission milestones for the City projects as well as guidance on the content and approach for the Contract Documents and cost estimating. The Engineer is also directed to carefully review the City's design related guidance document entitled ***Standard Design Criteria Manual.*** This document addresses the City's detailed design process and is a necessary companion document to this Manual.

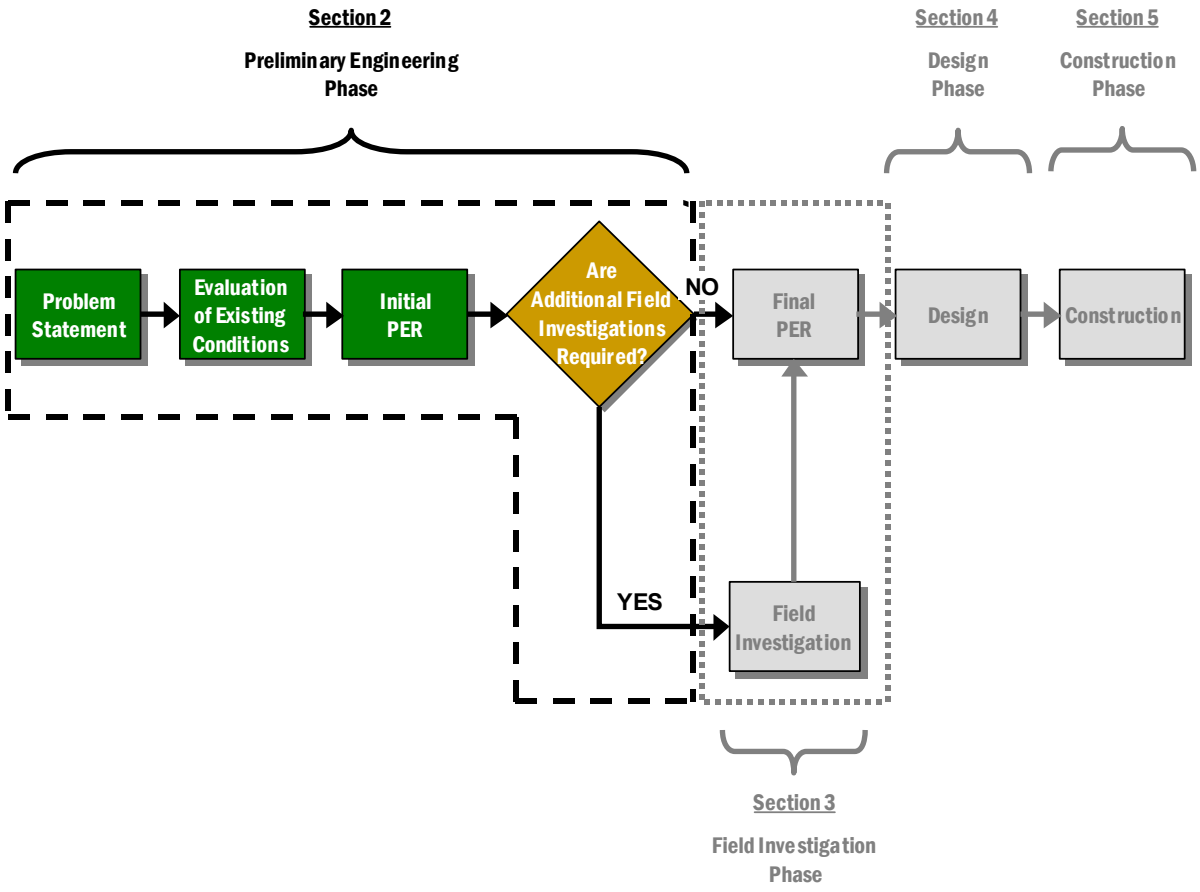
The ***Construction Phase*** (Section 5) is discussed in the context of the City's sewershed investigation program. The information presented in this section presents the office and field services required by the City, including optional services such as special inspections and post construction flow monitoring.

In general, the reader will find that each section of this document provides detailed information on individual phases of the work outlined above. The main focus of this document is to provide guidance for the *Preliminary Engineering Phase* and *Field Investigation Phase* of the sewershed investigation program. Further detailed guidance for design is provided by the City's ***Standard Design Criteria Manual***. Both of these documents should be reviewed by the Engineer prior to conducting a sewershed investigation.

Utilities strives for continuous improvement. Comments or suggestions for the improvement of this document are welcomed. Please send comments or suggestions to:

Engineering Manager
City of Norfolk
Department of Utilities
400 Granby Street
Norfolk, VA 23510

Figure 2-1
Preliminary Engineering Phase Outline



SECTION 2
PRELIMINARY ENGINEERING

2.1 OVERVIEW

2.1.1 General

A sewershed investigation project consists of the detailed study and evaluation of the proposed sanitary sewer project area, which may include gravity sewers, pumping stations and/or force mains. Engineering services include review of existing information, assessment of facility needs, field investigations, determining alternative plans for remediation, making recommendations, and developing requirements for final design documents and implementation plans.

The approach utilized by Utilities in sewershed investigations for the Preliminary Engineering Phase consists of three basic steps:

- Definition of the Problem Statement,
- Evaluation of Existing Conditions, and
- Preliminary Engineering Report.

A schematic outline of these steps and their context within the overall project is presented in Figure 2-1. This work is discussed in detail in this Section.

Figure 2-1
Preliminary Engineering Phase

(Located at the beginning of this section)

2.2 DEFINITION OF THE PROBLEM STATEMENT

In general, all sewershed investigations are initiated with a *problem statement* that establishes the need for remedial actions and their objectives. The problem statement may encompass some or all elements of the System, including gravity sewers, pumping stations, and force mains. This problem statement represents the driving force for each specific project listed in the Capital Improvement Plan (CIP). *One of the first steps in the sewershed investigation process is to precisely define this problem statement and utilize this information as the focus for developing an appropriate and cost effective project.*

In order to frame the problem statement and conduct sewershed investigations that are consistent with the City's SSES program, the following key objectives must be considered:

- *SSO Control* – A key objective of the SSES program is the control of SSOs throughout the System. Where there is a history of SSOs in the sewershed, the Engineer should evaluate how SSOs are related to O&M requirements (see below), hydraulic capacity or asset conditions. The Engineer should investigate SSO characteristics such as: location within the system, occurrence during dry and wet weather periods, recurrence interval, and whether any measures have been taken by the City to remedy the reported SSOs.
- *I/I Reduction* – This is an important objective because of the limited wet weather hydraulic capacity of the System and resultant impacts on SSO control. High Rainfall Derived Infiltration and Inflow (RDI/I) also has the potential to impact negatively the HRSD conveyance system.
- *O&M Considerations* – A third objective of the SSES program is to address O&M related needs of a sewershed. In order to reduce the potential for SSOs Utilities' has an ongoing, routine (weekly through monthly) sewer-cleaning program for areas of the System that have a propensity for root intrusion and/or grease accumulation. Other concerns include increasing the size of 6-inch mains serving too many homes and maintenance problems associated with backyard sewers. These problematic areas should be considered for remediation efforts during the sewershed investigation. O&M issues at the pumping stations are also to be reviewed, including equipment reliability and maintenance frequency.
- *Asset Upkeep Requirements* – There are assets in the sewershed that are nearing the end of their useful life or are in poor structural condition. These assets must be considered for upgrade to:
    - Insure that no failures occur in the foreseeable future
    - Restore the life expectancy of the asset, and
    - Maintain the overall service life of the System.

2.3 EVALUATION OF EXISTING CONDITIONS

The next step in the preliminary engineering phase of the project is *evaluation of existing conditions*. This step includes:

- Coordination meetings with Utilities and appropriate agencies,
- Review of existing information,
- Field reconnaissance, and
- A preliminary condition assessment.

2.3.1 Coordination

2.3.1.1 *Kickoff Meeting and Scope Confirmation with the Department of Utilities*

The Engineer should organize a kickoff or project initiation meeting, including key members of Utilities' Engineering and Operations staff as well as members of the project team. Objectives of this meeting are to:

- Establish communications procedures,
- Confirm the approach to be used for project evaluations and field work,
- Verify report and design requirements,
- Review information to be provided by the City,
- Review project schedule and set milestone dates, and
- Establish protocol for contacts and coordination with agencies outside Utilities.

2.3.1.2 *Agency Coordination*

The Engineer shall coordinate efforts with various City, state, regional and federal agencies. These agencies may have some jurisdictional control or influence over the project and should be contacted as early as practicable to obtain their timely input and minimize potential project delays. These agencies include but are not limited to the following:

- City of Norfolk, Department of Public Works
- City of Norfolk, Department of Planning and Community Development
- City of Norfolk, Division of Parks and Urban Forestry
- Hampton Roads Sanitation Districts (HRSD)
- Norfolk Redevelopment and Housing Authority (NRHA)
- Virginia Department of Health (VDH)
- Virginia Department of Environmental Quality (DEQ)
- Virginia Department of Natural Resources (DNR)
- Virginia Department of Transportation (VDOT)
- Virginia Marine Resources Commission (VMRC)
- U.S. Army Corps of Engineers (COE)

Because of the close interrelationship between the City's collection system and the HRSD conveyance system, the Engineer must insure proper coordination with HRSD including, as appropriate, a preliminary meeting held with representatives from their Operations and Engineering Divisions. This meeting should be held with Utilities' representatives present for the City.

2.3.2 Review of Existing Information

2.3.2.1 *Prior SSES and Other Documents*

In July 2003, the City completed a Comprehensive Sanitary Sewer Evaluation Survey and Long Term Control Plan, which received approval form the DEQ on December 12, 2003. This SSES program evaluated existing conditions and prioritized future needs for the System; it serves as a foundation for the City's CIP for the next 15 years.

The SSES prioritization of the sewersheds remediation projects included analysis of the following parameters:

- An initial estimate of potential volume of I/I reduction in each sewershed (i.e., gallons per day),
- The cost effectiveness of removing this I/I volume (dollars per gallon of I/I removed),
- Flows generated by each sewershed after I/I removal, both in total and as a percent of the total System flow.

The Engineer shall obtain information on these parameters from Utilities for consideration in the sewershed investigation.

The Engineer should also review prior studies, design reports, construction documents, as-built drawings and other available documents. Relevant information should be incorporated into the sewershed evaluation. The City has had an I/I program ongoing for approximately 15 years, to prioritize repair and maintenance of the collection system. A listing of the previous projects, through 2003, is included in Appendix A and copies of these documents may be available from the City. The Engineer is also to insure that studies, reports and project work completed since this time are included as part of the evaluation of existing conditions.

2.3.2.2 *Engineering and Operations Information*

Sewer system information available from Utilities generally includes design reports, plans, trouble reports, IMS data and GIS mapping information. More specifically such information may include but not be limited to:

- City of Norfolk GIS mapping of the project area showing, at a minimum, rights-of-way and property lines, streets and roads, building footprints, addresses, contours and spot elevations, storm sewers and appurtenances, water distribution system and sanitary sewer systems.
- Master water and sewer planimetrics, sewer lateral and water intersection drawings and plans for water and sewer projects within the sewershed.
- Design drawings, pump curves, design reports and operating data (run time logs) for the sewershed.

- Information on City repair work, and maintenance logs for sewer facilities in the project area.
- Meter size and historical water consumption data for customers within the project area.

2.3.3 Field Reconnaissance

Each sewershed investigation should incorporate field reconnaissance at the beginning of the project to determine up-to-date O&M and existing condition information on the collection system. Some of this information is typically obtained through consultation with Utilities' Operations staff. The list below is representative of the types of issues that could be investigated with Utilities' O&M staff during field reconnaissance.

1. Based on the experience of the operations staff, where are the significant problem areas in the sewershed?
2. Have there been any significant recent changes in the patterns or type of sewer problems (overflows, stoppages, collapses, etc.) from those identified in the SSES or other prior studies?
3. Have there been repairs in the field by Utilities or contractors since the SSES (or other study) was completed?
4. Which sewer lines within the study area are currently on Utilities' routine cleaning program and do they correlate with past problem areas?
5. Can reported problems such as grit, grease, roots or inflow be substantiated through a preliminary inspection of critical manholes or sewer segments?
6. Are there any easement or right-of-way issues affecting the project, such as backyard sewers or the need for land or easement acquisition for a replacement pumping station?
7. What are the local issues regarding aesthetics, traffic control, site accessibility and constructability?
8. Is the pumping station force main manifolded with other City or HRSD pumping stations and are there discharge pressure issues?
9. Under what conditions and how long does the pumping station require all pumps to operate?
10. Under what conditions does surcharging occur in the system?

For pumping stations, field reconnaissance will incorporate a field visit to the pumping station. The Engineer and Utilities may or may not determine that a complete pumping station inspection be conducted initially in accordance with Section 3 of this Manual.

While there are many other questions that may bring pertinent information to bear on the project, the Engineer should generally use this phase of the project to assess the need for, and extent of, field investigations in the next phase of the sewershed investigation.

2.3.4 Preliminary Condition Assessment

The Preliminary Condition Assessment forms the basis for site-specific evaluations within the sewershed and for comparing the relative importance of sub areas within the sewershed for upgrade. As a minimum, the following parameters should be evaluated in order to assess existing conditions:

Mainline Sewer Pipes and Service Laterals

- Pipe Age
- Pipe Material
- Structural Condition
- Defect History
- Estimated Infiltration/Inflow (I/I) Rates
- Record of SSOs
- Recurrent Problems (e.g. grease, roots, collapses)
- Houseline Service Calls
- Pipe slopes/adverse grade
- Unsewered areas

Manholes

- Structural Condition
- Surcharging or SSOs
- Inflow Potential
- Recurrent Problems

Additionally, key priority indicators of the sewershed conditions, which may be used to establish Utilities' rehabilitation priorities consistent with the SSES evaluations include:

- **SSOs Reported Since Fiscal Year 2001:** Reported SSOs can be an indication of problems in the gravity sewer system and may require some type of SSO control measure. Project areas with a higher number of reported SSOs have a higher priority for rehabilitation depending upon the causes identified.
- **Mainline Sewer Age:** The age of the mainline sewers in a sewershed is an indicator of the need to re-capitalize the mainline sewer assets. Older gravity sewers have a higher rehabilitation/replacement priority.

  As an initial and general indication of the predominant age of the sewers in each sewershed, the following Figure 2-2 is provided for the Engineer's preliminary condition assessment plan. The Engineer should confirm this information through as-built information and other Utilities' resources during the preliminary engineering phase.

Figure 2-2
Norfolk Sewersheds –
Predominant Age of Sewers

(Located at the end of this section)

- **Mainline Sewer Structural Assessment:** During the SSES program, structural ratings for the mainline sewers were developed based upon the SSES field investigations and Utilities' Hansen Information Management System (IMS) scoring methodology. These ratings were then used to characterize an average structural rating for each existing pipe material type in the sewer system. The resultant general structural rating system for Norfolk's existing System is as follows:

Existing Mainline Sewer Assessment
Structural Rating by Pipe Material

Mainline Pipe Material	Structural Rating
Vitrified Clay	40.3
Concrete	33.5
Extra Strength Vitrified Clay	30.9
Cast Iron	11.7
Ductile Iron	10.0
PVC, ABS, Truss, Asbestos Cement	3.8

The lower ratings represent better structural conditions and the higher ratings represent worse conditions. Ratings in the above table offer an indication of the relative structural condition that could be expected of the various pipe materials in the Norfolk System. However, the Engineer should exercise caution in use of this information and should generally develop site-specific information.

Current Utilities GIS information on pipeline materials in the sewersheds was developed during the SSES, with the results shown in Figure 2-3 and more detailed information provided in Appendix B. However, during the sewershed investigation there are at least two additional issues that should be confirmed:

1. Since some of the current (GIS) information on pipe material is undetermined, the Engineer should develop and implement a (field) investigation plan which will accurately assess the pipe conditions in those portions of the basin with pipe materials as yet undetermined, as well as those with known pipe materials, and
2. Subsequent to the SSES, Utilities has determined that some rehabilitation projects in which polyethylene slip lining was used (especially those conducted during the 1990's) have presented, in certain reaches, problems that include separation of the lining from the host pipe or collapsed linings. Accordingly, the Engineer should develop their own assessment of the condition of the sewershed areas that had previously been slip lined.

Figure 2-3
Norfolk Sewersheds –
Predominant Material of Sewers

(Located at the end of this section)

- **Backyard Sewers and Limited Access:** The presence of backyard sewers and other sewers with limited access for maintenance is considered an important factor in determining the priority for corrective action. However, this condition must be carefully weighed against other factors in the overall prioritization of needs.
- **Presence of Concrete Pipe:** The presence of concrete pipe, for mainline sewers, is a key prioritization factor. The continued deterioration of concrete pipe is a problem in the sewer system, primarily because of age and the loss of the bonding agents (cement and aggregate). Older concrete pipe has exhibited a greater potential for catastrophic failure than other mainline sewer pipe materials.
- **Mainline Sewers Below Groundwater:** Sewers below the groundwater table would have a higher priority for upgrade because of the greater infiltration potential.

For pumping stations, the condition assessment will evaluate similar characteristics such as age of the station; upgrade history of the station; operating and maintenance issues; capacity to handle both dry and wet weather flows; and ability to handle wet weather conditions without detriment to any other pumping stations or force mains, including HRSD pumping stations and force mains.

The Engineer shall perform a preliminary assessment incorporating both existing background information and information compiled during the field reconnaissance. This assessment shall include an evaluation of the conditions and the needs in the sewershed and a preliminary prioritization of those needs. A Pumping Station inspection checklist is discussed further in Section 3 of this Manual and is presented in Appendix F for reference.

2.4 PRELIMINARY ENGINEERING REPORT

2.4.1 General

The Engineer shall provide a detailed Preliminary Engineering Report (PER) to document the analysis phase of the project.

The format and content outlined in this Manual is consistent with the Commonwealth of Virginia's State Water Control Board Sewage Collection and Treatment Regulations (SCAT), (VAC 25-790). The Engineer is responsible for insuring that the PER conforms to all applicable regulations and for inquiring with the State of Virginia Department of Environmental Quality (DEQ), in coordination with Utilities, whether or not submittal of the PER to the DEQ is required.

2.4.2 Preliminary Engineering Report Format and Checklist

The following format for a PER is to be utilized by the Engineer in documenting all sewershed investigations on behalf of the City. The applicable general requirements of the SCAT regulations are cited in the State Code at 9 VAC 25-790-110 and 9 VAC 25-790-940 and should be used as appropriate.

- TITLE PAGE
  - General SCAT requirements
  - Professional Engineer's seal and signature
  - (State) Grant or Loan number, when appropriate
- TABLE OF CONTENTS
- EXECUTIVE SUMMARY
- INTRODUCTION
  - Purpose
  - Scope
  - Background
- METHODOLOGY & INVESTIGATIVE APPROACH
  - Approach to Work
  - Methodology – both field investigations and engineering evaluations
  - Governing HRSD, SCAT and City Requirements
- EXISTING FACILITY EVALUATION
  - Inventory of Collection System
  - Summary of Results of Pumping Station Inspection
  - Condition Assessment Evaluation
  - Field Investigation Results
- DEVELOPMENT OF FLOWS AND CAPACITY ASSESSMENT
  - Population (Residential) Information
  - Design Flows based on zoning and planning information
  - Water Usage for base flow development
  - Development of Peaking Factors and use of existing data
  - System Capacity Assessment – Dry weather, wet weather and critical reach
- EVALUATION OF ALTERNATIVES
  - Development of Alternatives

  - Advantages and Disadvantages of Each Alternative
  - Institutional Considerations
  - Project Cost and Life Cycle Cost Analyses.
- FINDINGS, CONCLUSIONS & RECOMMENDATIONS
  - Discussions of Findings
  - Recommendations
  - Breakdown of specific areas within the sewershed where rehabilitation or replacement is recommended.
- SELECTED PLAN & CONCEPTUAL DESIGN
  - Hydraulic evaluation (Pump-system curves and collection system capacity)
  - Conceptual Bases for Design
    - Hydraulics (HRSD, SCAT, SSES)
    - Structural/Architectural
    - Mechanical
    - HVAC & Odors
    - Instrumentation & Control Monitoring (e.g. Alarms, SCADA)
    - Materials (i.e.: pipe material, coatings, linings suitable for the job)
  - Conceptual Design Drawings (e.g.: Site Plans, Floor plans, layouts and conceptual schematics)
  - Recommended Project Phases
  - Staging Plans and other special construction considerations
  - Property and easement considerations
  - Identify permits required from local, state and federal agencies
  - Identify Public Outreach Needs
  - Funding Requirements
- APPENDICES
  - Field Data (Compiled Raw & Analyzed)
  - Supporting Calculations for Engineering Evaluations
  - Conceptual Drawings
  - Supplemental Design Information
  - System overview and detailed (oversize) maps, for all project types

This format is a general guideline to be used by Engineers in all City sewershed investigations; each sewershed project will involve some or all of the elements of each section of the PER. For DEQ-mandated PERs, the Engineer should follow the above format while including any additional information in accordance with SCAT regulations.

In order to assist Engineers and guide Utilities in evaluating the completeness of a PER submission, a checklist has been developed which outlines the information to be included in the PER submittal. This PER checklist is included in this guidance document as Appendix C. The Engineer should include an original, completed (signed) checklist form with the transmittal to Utilities for each PER submission(s).

2.4.3 Engineering Evaluations for the PER

The following subsections provide guidance on some key elements of the PER development. These include:

- Adjacent Sewershed Considerations (i.e.: Review of the interactions of the sewershed under investigation with adjacent sewersheds, and any potential impacts of remedial actions on adjacent sewersheds)
- Evaluations for Gravity Sewers (I/I reduction)
- Evaluations for Pumping Stations
- Evaluations for Force Mains
- System Capacity Assessment (i.e.: assessment of the combined capacity of the gravity sewers, pumping station and force main working as an integrated system)
- Analysis of Alternatives
- Development of Recommendations
- Public Outreach

2.4.3.1 *Adjacent Sewershed Considerations*

In order to assess sewershed issues in a comprehensive manner, the study area must be considered in the context of its interaction with the entire City System and the HRSD interceptors and pumping stations. The following are a few examples of representative upstream and downstream conditions that must be considered in the sewershed investigation:

- Upstream Conditions:
    - Upstream Pumping Station Discharging into sewershed under study
- Downstream Conditions:
    - Sewershed under study Discharges into HRSD system
    - Sewershed under study Discharges into a City Pumping Station

These conditions represent a generalization of the many variations that exist within the Norfolk system. Some of these examples of typical sewershed project areas are shown schematically in Figure 2-4, including their interrelationship with other City sewersheds and HRSD facilities. There are still others that have not been represented here. For a more representative picture of a particular sewershed, a detailed City of Norfolk collection system hydraulic network schematic, showing the City and HRSD collection and conveyance facilities, is presented in the SSES Report as Figure 3-7.

Figure 2-4
Schematic Example of Sewershed Project Areas

(Located at the end of this section)

As seen in these schematics, HRSD's conveyance system consists of a combination of gravity and force main interceptors, pumping stations and in-line booster stations (pressure reducing stations). The HRSD facilities convey wastewater to one of three HRSD wastewater treatment plants (WWTP) serving the City: the Chesapeake-Elizabeth Plant, the Army Base Plant and the VIP Plant. Accordingly, the interconnection amongst City sewersheds and their potential impact on the HRSD facilities is a key evaluation criterion in the sewershed investigations.

2.4.3.1.1 Upstream Pumping Station Discharge

Due to the flat topography in the City of Norfolk, there are numerous sewersheds that receive flows from upstream pumping stations. The upstream pumping station discharges can be either at the sewershed boundary or in a few cases into (or near) the wet well of the sewershed pumping station. In some instances, this "piggyback" sequence of pumping stations "in series" may occur over several sewersheds. In these cases, the evaluation of a sewershed may require an initial investigation regarding the nature of the upstream pumping station controls and flow impacts on the project area. Also, there can be unique problems associated with the force main discharge into the study area. Examples may include corrosion in the gravity sewers due to the high sulfide content of forcemain releases or the potential for surcharging or overflows where the force main enters the gravity sewers in the sewershed.

2.4.3.1.2 Discharge into HRSD System

There are 61 City connection points to the HRSD system, 42 of which are pressure connections. HRSD policy has established pressure criteria at the point of connection to their force main system. The Engineer must take these criteria into consideration when conducting sewershed investigations and developing recommendations. As mentioned previously, during the initial project coordination phase, the Engineer and Utilities will need to initiate consultation with HRSD regarding specific conditions at each point of connection to the HRSD system.

2.4.3.1.3 City Pumping Station Discharge

Many City pumping stations discharge into a City force main interceptor, which also receives flows from other City pumping station(s). This manifold force main scenario is similar to that of discharging into a HRSD force main. In these cases, the Engineer must conduct a hydraulic evaluation of the potential impact of a given pumping station discharge on other affected stations. The Engineer should consult with the City during the early phases of the sewershed investigation regarding use of information obtained from Utilities' hydraulic model of Norfolk's System.

2.4.3.2 *Evaluations for Gravity Sewers (I/I Reduction)*

2.4.3.2.1 General

In order to determine the I/I reduction potential, the Engineer must first quantify the base sewage flow, the Dry Weather Infiltration (DWI) and the RDI/I.

2.4.3.2.2 Base Sewage Flow

Water consumption data for the sewershed for a two-year (minimum) period should be obtained from Utilities and used for the base sewage flow evaluation by determining the portion of metered water consumption that is returned to the sewer system as sewage flow. The Engineer should follow the water consumption requirements request procedure presented in Appendix D. An estimate of Sewage Return Factors, based on land use in each of the metered areas, was made during the SSES program with the following results:

SEWAGE RETURN FACTORS

General Land Use	Sewage Return Factor
Primarily Residential	0.80 percent
Mixed Use (Residential/Commercial/Industrial)	0.87 percent

These factors may be used, subject to confirmation by the Engineer of their applicability, for the specific sewershed under investigation.

2.4.3.2.3 Dry Weather Average Daily Flow (ADF)

The flow at each flow-monitoring site can be used as the basis for determining the dry weather ADF for the metered areas and for estimating the dry weather infiltration entering the gravity sewers. In determining the ADF, days with rainfall (and the following 3 days) are normally to be excluded from the analysis. Dry day flows are recorded at each monitoring site at 15-minute intervals and are averaged to determine the shape of the average diurnal curve for each metered area. The diurnal curve for each metered area represents the dry weather ADF and is used as the basis for hydraulic analysis.

2.4.3.2.4 Dry Weather Infiltration

Dry weather infiltration for each metered area can be estimated by subtracting the base sewage flow from the dry weather ADF. The 15-minute average low flow and the absolute lowest, non-zero flow (for the 3:00 to 5:00 AM period) are compared to determine which of the two recorded low flows provide the most accurate estimate of DWI. This comparison is made to address the potential impact of flows in transit from upstream areas. The metered low flow (average or absolute) that provides the best fit is selected as the estimated DWI for the metered areas.

2.4.3.2.5 Rainfall Derived Infiltration/Inflow

All flows during and after rainfall events above the dry weather diurnal curve represent potential RDI/I. The extraneous wet weather flow quantity for each monitoring site is divided by the total rainfall accumulation over the metered area to determine an RDI/I factor, expressed as a percentage of the total accumulated rainfall that entered the sewer system. Results of the SSES indicated that the RDI/I factor ranged from 0.1% to 5.3% with an average of 1.3% for all of the monitoring sites in Norfolk's System. The Engineer may follow this approach to determine an RDI/I factor for the sewershed under investigation.

2.4.3.2.6 Wet Weather Design Storm

Use of a design storm methodology provides a basis for comparing the impacts of different precipitation return frequencies and durations on the sewer system. This is important since it is assumed that a given percentage of the total rainfall during any storm will enter the sewers as RDI/I and that wet weather events will be of different (random) frequency and duration during a flow-monitoring program.

For purposes of I/I evaluation, rainfall events with an accumulation of over 0.5 inches are considered as significant events. This rainfall level is typically the break point below which there is no significant response to rainfall. The Engineer should confirm this observation for each specific sewershed as indicated by increases in metered flow during and after rainfall events.

2.4.3.2.7 Infiltration/Inflow Removal

The amount of DWI and RDI/I estimated to be removed by rehabilitation and/or replacement of mainline sewers, manholes and public service laterals will depend on the percentage contribution of the sewer component being upgraded and the efficiency of the upgrade technique in eliminating infiltration/inflow. Historically, collection system upgrade techniques cannot remove all infiltration/inflow entering the sewer system due to various factors including: the extent and type of repairs, construction quality, and extent of other I/I sources (such as private sewers, roof leaders, and area drains).

During the City's SSES, the following I/I reduction efficiencies were assumed for rehabilitation and replacement of sewer mainlines, manholes and houselines. These reduction efficiencies are provided for guidance; the Engineer shall provide an independent opinion of such anticipated removal efficiencies in the sewershed investigation.

Table 2-1
Estimated I/I Reduction Efficiency of
Rehabilitation and Replacement Techniques

Sewer Component	Upgrade Technique	Anticipated Infiltration Reduction Efficiency (%)	Anticipated RDI/I Reduction Efficiency (%)
Mainline Sewer	Rehabilitation	80%	80%
	Replacement	90%	90%
Manholes	Rehabilitation	80%	80%
	Replacement	90%	90%
Houselines	Rehabilitation	40%	40%
(Public Portion)	Replacement	50%	50%
Houselines	Rehabilitation	30%	30%
(Private Portion)	Replacement	40%	40%

2.4.3.2.8 Infiltration/Inflow Reduction Evaluation

Once the base sewage flow, the DWI and the RDI/I have been determined the Engineer must identify remedial actions to reduce I/I.

The SSES established overall system goals for I/I reduction based on I/I reductions in each sewershed. The Engineer shall consult with Utilities and obtain the expected I/I reductions for each sewershed under investigation. The Engineer should then make their own assessment of the expected performance of the proposed remedial actions. The Engineer should provide to Utilities a comparison of I/I reductions anticipated by the proposed remedial actions and those anticipated during the SSES.

2.4.3.3 *Evaluations for Pumping Stations*

This subsection describes a suggested approach for the evaluation of pumping stations. The approach is outlined in Figure 2-5 and comprises the following elements:

Figure 2-5
Pumping Station Evaluation Schematic

(Located at the end of this section)

Using a methodical approach, conduct an inventory and inspection of the pumping station. – This field investigation is described further in Section 3 of this Manual, including a standard inspection form (see Appendix F). The Engineer shall compare the results of the field conditions to the following criteria:

- SCAT Regulations – these regulations dictate all new pumping station construction and upgrades and govern such issues as firm and standby pumping capacity, wet well detention time, ventilation rates, etc. The Engineer's recommendations should include an assessment of the need to meet any or all of these criteria for existing pumping stations.
- Industry Standards – the Engineer is responsible for comparing the facility with industry standards such as general mechanical and electrical reliability, pump cycle times, and odor control issues.
- City Guidance and Needs – Utilities has established standards for pumping stations as outlined in the Standard Design Criteria Manual. In addition, there may be other specific needs such as SCADA system and flow metering capability at the station that should be evaluated.
- Operational Plan/Controls – The pumping stations should be evaluated for such aspects as provision for engine driven bypass pumping (temporary or permanent), standby emergency generator capability and emergency generator hook-ups. The Engineer shall consult with Utilities regarding emergency response provisions for any given pumping station.

Identify Requirements for Improvement. – This task encompasses a needs analysis of the pumping station considering all disciplines such as:

- Structural
- Architectural
- Hydraulics (HRSD, SCAT & SSES criteria)
- Process
- HVAC/Odors
- Monitoring (e.g Alarms, SCADA)

The Engineer should develop the bases for design including ADF, peaking factor, system head curves, pump control schemes and pump design capacity. Such peaking factor should be documented in the PER and be in accordance with the SCAT regulations for larger pumping stations (peaking factor of 2.5). The Engineer may propose a different peaking factor based on flow metering or SCADA data.

Analyze Findings, Evaluate Corrective Measures and Produce Conceptual Design. – General guidance for this element of the pumping station evaluation includes the following:

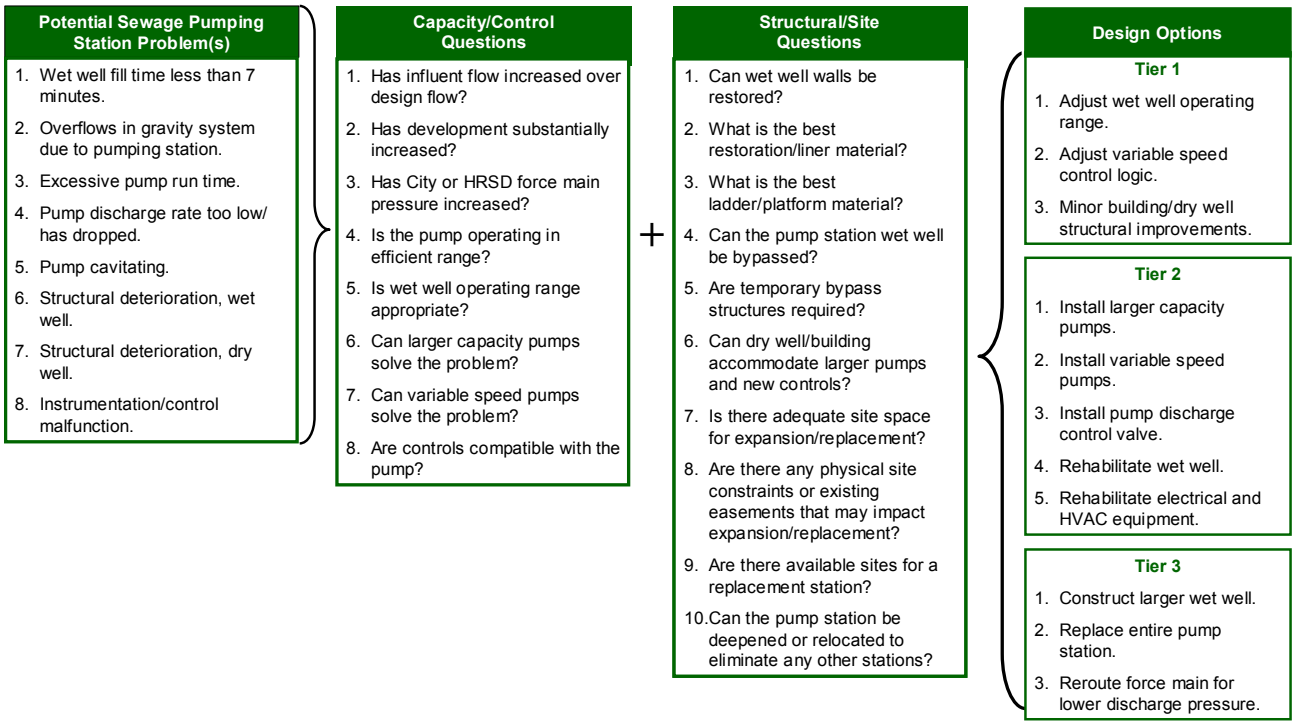
- Standardized Rehabilitation/Retrofit – The Engineer shall consult with Utilities to achieve, to the extent possible, a standardized approach to the rehabilitation or retrofit of the pumping station. At this point the Engineer must understand City Engineering and O&M staff preferences for types of equipment and facility layouts.
- Priorities – The Engineer may have to identify priorities for the proposed improvements. These priorities must anticipate any expected changes in future flows (mostly due to anticipated I/I reductions).
- Contract Approach – The Engineer shall set an approach to the contract documents that is consistent with the project phasing derived from the priorities described above.
- Budget – The Engineer must develop a project budget and an estimated spending schedule.

The following is a list of factors that should be considered by the Engineer in evaluating pumping stations:

- **HRSD Force Main Pressures:** Pumping stations that have capacity limitations due to high HRSD force main connection pressures.
- **Capacity Evaluation/SSO Impacts:** The Engineer shall provide, as part of the hydraulic analysis, an evaluation of the pumping station capacity compared to the incoming flow. The Engineer shall make an assessment of the potential for SSOs under current and future conditions.
- **Age Rating:** The approximate year the pumping station was built or significantly upgraded normally has a bearing on the general mechanical and structural condition of the station.
- **Structural Evaluation:** The structural rating is based on evaluation of such elements as concrete condition in the wet well and dry wells, superstructure condition, roof condition, etc.
- **Pumps/Motors/Controls:** The pumps/motors/controls assessment must carefully evaluate both present and future conditions. Complementary factors such as wet well size, pump cycling and need for future capacity may impact the evaluation.

A proposed approach to pumping station problem assessment is shown in Figure 2-6. As shown on this figure, various upgrade options may be determined. These options can vary from a relatively minor upgrade (Tier I) with a lower capital cost, to a more extensive upgrade (Tier III) with a higher capital cost. The objective of the engineering evaluation should be to resolve the pumping station problems using the most cost effective solution.

Figure 2-6
Sewage Pumping Station Problem Assessment



2.4.3.4 *Evaluations for Force Mains*

Each of the Norfolk pumping stations has a force main which discharges to a downstream gravity sewer, force main connection or into a wet well.

Some of the force mains have a history of breaks resulting in reported SSOs. Even though SSOs due to force main breaks are very infrequent as compared to SSOs from gravity sewers, the volume of wastewater that can be released from a force main break is typically greater. The condition assessment of force mains is an integral part of any sewershed investigation.

Force mains can be evaluated based on pipe material, age, reported condition, and occurrence of SSOs. Additional factors that should be considered in making an assessment of the overall hydraulic, mechanical and structural condition of the force main, include:

- Capacity for both present and future flows based on accepted pipeline velocities.
- Impact on pumping stations receiving discharges from the force main in the study area.
- Potential need for discharge location rerouting in order to mitigate a downstream hydraulic bottleneck.
- Force main replacement in lieu of an extension, due to concerns for the life expectancy of the piping (asset management).

The need for upgrading, rehabilitating, replacing, extending or rerouting a force main should be based on the overall evaluation of these various factors.

2.4.3.5 *System Capacity Assessment*

2.4.3.5.1 General

The objective of the capacity analysis is to determine if there are hydraulic capacity limitations in the sewer system that could contribute to or cause SSOs or surcharging. The following conditions, as a minimum, must be determined for each sewershed:

- Wastewater flow characteristics during normal (dry weather) conditions
    - Is sewer capacity adequate during normal dry weather conditions?
    - Is the pumping station capacity adequate under normal dry weather conditions?
- Wastewater flow characteristics during wet weather
    - Is sewer capacity exceeded under various design storms?
    - Is pumping station capacity adequate under various design storm conditions?
    - Do pumping station discharge conditions (e.g. HRSD force main pressure) limit capacity?
    - Will the pumping station have adequate capacity in the future after sewer rehabilitation is complete?
- Critical Reaches of the collection system
    - What specific reaches of the collection system do not have adequate capacity due to slope or size for the above conditions?

In order to address these questions, the Engineer shall conduct a hydraulic analysis of the gravity sewers, pumping station and force mains.

2.4.3.5.2 Flow Development

Development of flows for purposes of capacity analysis can be accomplished in various ways:

- Compilation of water use data for the study area for a two-year period, incorporating Return Sewage Factors as outlined previously in this Section.
- Planning data from the Health Department and the SCAT regulations, providing flows based on zoning classification.
- Population based flows, after development of service area population from such sources as the Census, HRPDC and other local agencies.
- Flow metering for the sewershed to develop dry and wet weather flow characteristics of the system.
- Operation (historical) data from the specific sewershed in the system based on information such as pump run times, force main flow meters and other means.

The methodology proposed by the Engineer should be discussed with Utilities at the kickoff meeting and a detailed plan of action for developing such flows delineated at that time.

Flows must be developed for both average and peak conditions. Peaking factors may be developed based on flow metering or use of industry-accepted factors. A comparison of flows based on use of SCAT, HRSD, or City criteria is presented in Table 2-2 as guidance for Engineers and Utilities' staff.

Table 2-2
Design Basis for System Flows

Flow Criteria	Description	SCAT	HRSD	City of Norfolk
Average Daily Flow (gpcd)	---	100 (1)	100 (2)	89 (3)
Peak Daily Flow (gpcd)				
- Laterals	Sewer with no other common sewers discharging into it.	400	-	400
- Submains	Sewer that receives flow from one or more sublaterals	400	-	400
- Main or Trunk Line	Sewer that receives flow from one or more submains	250	-	(5)
- Interceptors	Sewer that receives flow from a number of gravity mains, trunk sewers, force mains, etc.	200	200 (4)	(5)

Notes:

1) An average daily flow (ADF) of 100 gallons per capita per day (gpcd) is assumed based on an allowance for reasonable infiltration but without an allowance for inflow.
2) For HRSD, an average daily flow of 100 gallons per capita per day (gpcd) is assumed based on a water consumption of 83.33 gpcd plus a 20 percent safety factor [83.33 + (83.33 x 20 percent) = 100].
3) Average daily wastewater flow for the City is based on the SSES evaluation of Citywide average water consumption. Individual sewershed water use and base flows should be developed when possible.
4) For HRSD, a peak daily flow of 200 gpcd is assumed based on a peak factor of 2.0 times the average daily flow per capita or 2.4 times the daily water consumption flow per capita. The 200 gpcd includes acceptable levels of infiltration/inflow.
5) For the City of Norfolk System and for sewershed investigation purposes, the City guidance is to follow the SCAT and HRSD criteria to the extent reasonably and economically possible. However, peak flow criteria for individual sewersheds may deviate (either higher or lower) from these criteria based on a detailed sewershed analysis, as described in the following section.

As a result of the sewershed investigation, the bases for design (flows) for the City's System for rehabilitation projects would normally follow the SCAT regulations but may differ from SCAT or HRSD guidance for one or more of the following reasons:

- The SCAT regulations are based on an allowance for infiltration but no allowance for inflow. The sewershed investigation may document greater quantities of infiltration and inflow that cannot be economically removed in this specific area of the System.
- The HRSD criteria are primarily based on interceptors; much of the City's System is considered as mains rather than interceptors and therefore the SCAT peak flow of 250 gpcd would apply.

2.4.3.5.3 Hydraulic Modeling

Norfolk's System has been modeled using the XP-SWMM program for all gravity sewers, pumping stations, and force mains. The Engineer shall discus with Utilities the need for reviewing model results or for having Utilities conduct additional model runs in order for the Engineer use this additional information to develop, evaluate and recommend rehabilitation alternatives.

2.4.3.6 *Analysis of Alternatives*

Results of the engineering evaluation may suggest several viable alternatives for providing the City with an upgraded, reliable sewer system. The Engineer will review with Utilities those alternatives that appear the most feasible and evaluate up to three alternatives based on various factors such as advantages and disadvantages, net benefits to the City, project costs, life cycle costs, permitting, impacts on the neighborhood, and any other pertinent factors.

A detailed discussion of various sewer rehabilitation alternatives and an approach to consideration of alternative technologies for sewer rehabilitation purposes for the study area is included in Appendix E.

Some additional considerations for selection of rehabilitation or replacement options are as follows:

- Because rehabilitation is in most cases less expensive than replacement (and less disruptive), the additional expense to achieve a marginal increase in reduction may not be warranted in specific situations. Other factors such as less surface disturbance and adverse neighborhood and traffic impacts can make rehabilitation by sewer lining more attractive.
- Replacement of mainline sewers and manholes is more appropriate where structural deterioration is so severe that rehabilitation techniques are not practical and where other factors such as hydraulic capacity limitations, sags, deficient slopes and backyard sewers may exist. Also, there may be situations where the amount of rehabilitation is so limited that replacement should be considered.

The Engineer should develop cost estimates for the PER (alternatives and the recommended plan) based on the guidance in Section 4 of this Manual.

Results of the sewershed evaluation should include, as a minimum, the following informational parameters:

- Percent sewershed to be upgraded (%)
- Types and locations of sewer rehabilitation, repairs and replacement
- 10-year design storm flow estimated to remain after the project (gpcd)
- Total sewer project upgrade cost
- Cost per gallon I/I removed (DWI and RDI/I)

2.4.3.7 *Recommendations*

The recommendations proposed by the Engineer shall be of sufficient detail to provide justification to Utilities, funding agencies and local residents regarding the need for and cost of projects. Recommendation of the PER shall include as a minimum:

2.4.3.7.1 Identification of Additional Field Investigations

The Engineer shall identify any additional field investigations needed. A suggested approach for identifying the type of investigation and a phasing plan for implementing additional detailed field investigations is outlined in Section 3 of this Manual. In certain cases, the field reconnaissance phase of the project may provide sufficient basis for proceeding with the design phase of the project. Accordingly, one of the requirements of the Initial PER is for the Engineer to determine that either:

a) Additional Field Investigations are required

b) No additional Field Investigations are required

In the first case, the Engineer should develop a detailed work plan and proceed with the Field Investigations phase of the project after approval and authorization by the City. Results of the investigations are to be incorporated into a Final PER. In the latter case, the Engineer can proceed directly to the Final PER once Utilities has commented on the Initial PER and accepted the recommended project and approach.

2.4.3.7.2 Implementation Aspects

Another important aspect of the PER is an assessment of the cost, phasing and approach for implementing the project. Based upon the results of the sewershed investigation and the alternative analysis described above, there may be a need to phase the project (break-up into several contracts) or to complete the project over several fiscal periods. Examples of the need for such phasing may include:

- The estimated project cost exceeds the current fiscal year budgeting for the specific project.
- There are various neighborhoods in the project area that should not be disrupted at the same time.
- There are various types of projects involved, i.e. pumping station and sewer rehabilitation, which may require different contracting specialties.
- There is a need to fast track a project, due to local circumstances, community activities, or planned roadway improvements.
- The project may be subject to outside institutional influences such as HRSD scheduling, NHRA Projects, etc.

The Engineer must evaluate these and other issues to develop an approach to implement the project that meets the City's needs. The overall approach to the project phasing should be outlined in detail in the PER with a description of the various phases of the work included and the associated costs and schedule of each phase.

2.4.3.7.3 Conceptual Design

2.4.3.7.3.1 *Content and Scope of Design*

For Utilities, the scope of the Conceptual Design represents an approximate 15% design point. Such conceptual scope is differentiated from later design stages primarily in the level of detail involved. The following sections present some guidance on information required of the conceptual design.

2.4.3.7.3.2 *Conceptual Drawings*

The Engineer shall develop base mapping for the project area using GIS and/or AutoCAD mapping provided by Utilities in electronic format and augmented by field surveys conducted by the Engineer. The conceptual drawings for sewer rehabilitation should include at the least the following:

- Existing Conditions
    - Project mapping including:
        - System layout
        - Results of the Conditions Assessment
        - Identification of existing conditions requiring remedial actions
    - Identification and prioritization of sub basins in sewershed
    - Identification of Critical Reaches of Sewers
- Recommended Plan
    - Project mapping including:
        - Replacement Sections
        - Abandonment Sections
        - Rehabilitation sections:
            - Point Repair Locations/Streets
            - Manhole Repairs
            - Lining Locations/Streets
            - Other (e.g. pipe bursting)

For pumping station projects, conceptual drawings shall include:

- Base mapping showing main physical features such as:
  - Driveways, major trees and landscaping
  - Utility locations for overhead and underground utilities
  - Adjacent sewer and force main information
  - Topographic information such as contours, swales, culverts, etc.
  - Other pertinent information
- A site plan identifying adjacent property owners, property lines and easements on site
- Layout of the existing facilities
- Layout of the proposed facilities
- Initial floor plans
- Flow schematics
- Any other drawings deemed necessary by the Engineer or required by the SCAT regulations for submission to the DEQ

In all cases drawings will be prepared at a scale suitable for use in the FINAL DESIGN.

The Engineer shall also provide sufficient information to determine the constructability of improvements on the site. Plans must meet the requirements of the City's Site Plan Review Committee guidelines outlined in the City's Standard Design Criteria Manual.

2.4.3.7.4 Permits

In order to minimize any potential delays to the project, the Engineer should insure, in coordination with Utilities, appropriate and early coordination with:

- Local, state and federal agencies.
- Adjacent property owners.
- MISS UTILITY companies such as Virginia Natural Gas, Dominion Virginia Power, Cox Cable and any other utility companies that may be affected or that may impact on the routing, location or other design aspects of the City's project.
- Any others identified by the Engineer.

The Engineer shall also identify any permits and approvals needed from the above stakeholders and the estimated time required to obtain said permits.

2.4.3.8 *Public Outreach*

Communication with the local community is essential to the success of any Utilities project. The Engineer must coordinate with Utilities and other City agencies prior to establishing any contact with the public on the project. These efforts generally involve:

- Keeping the local community informed as the project proceeds.
- Soliciting input from the community during the investigation phase of the project.

The Engineer will assist Utilities with public outreach over the course of the sewershed investigation project. Typically two or more public meetings would be involved. An initial meeting would involve informing the community of the goals and objectives of the project during the PER phase and soliciting their input regarding concerns they would like to see addressed as part of the project. Subsequent meetings could present the recommended design approach, the nature of the work proposed, the schedule and the anticipated impact on the neighborhood during the construction phase.

The Engineer should also endeavor to utilize other means of communicating with the affected public such as neighborhood flyers, door hangers, newsletters, web pages, and other community communication formats in the most effective manner.

Figure 2-2
Norfolk Sewersheds –
Predominant Age of Sewers

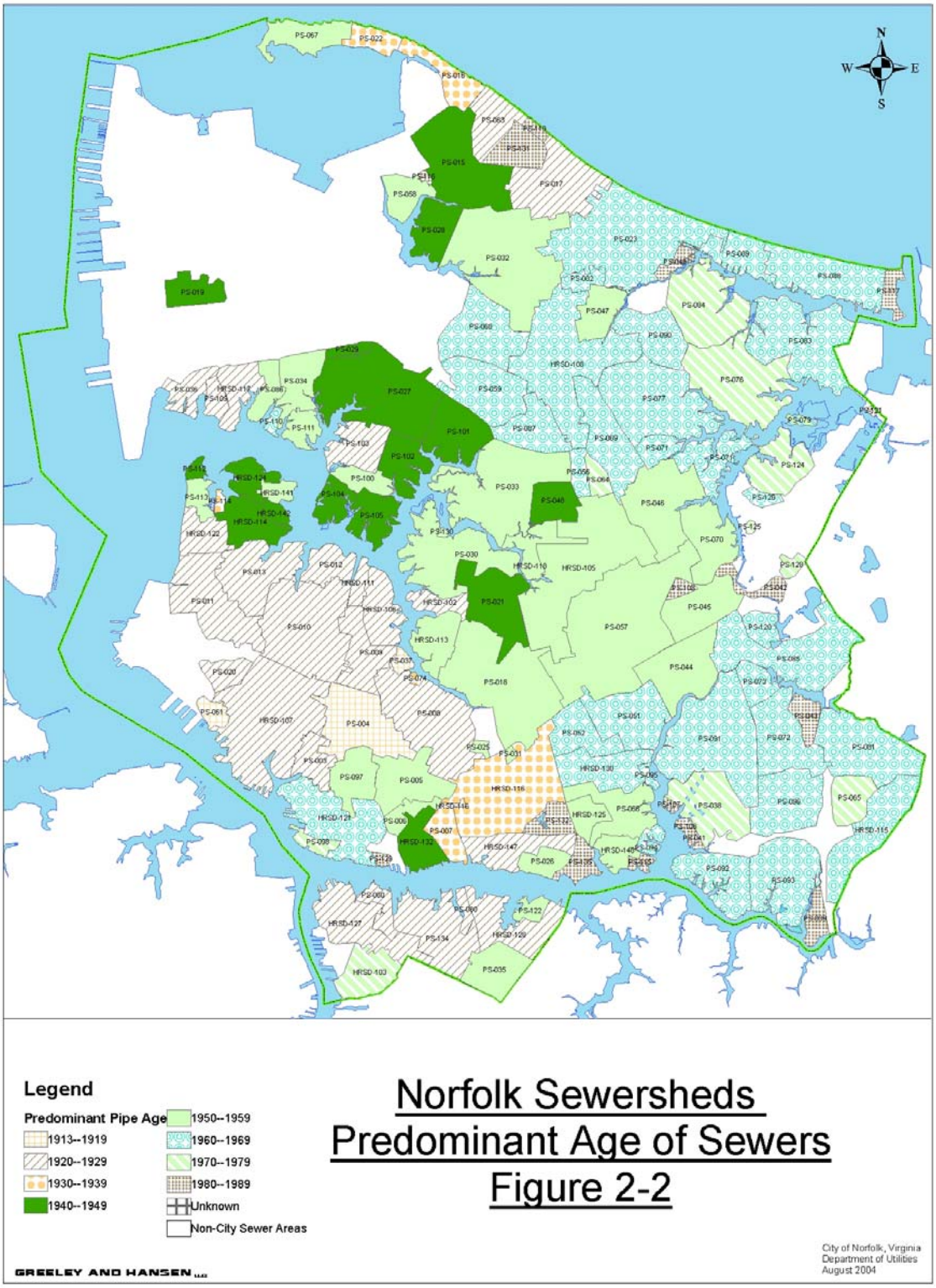


Figure 2-3
Norfolk Sewersheds –
Predominant Material of Sewers

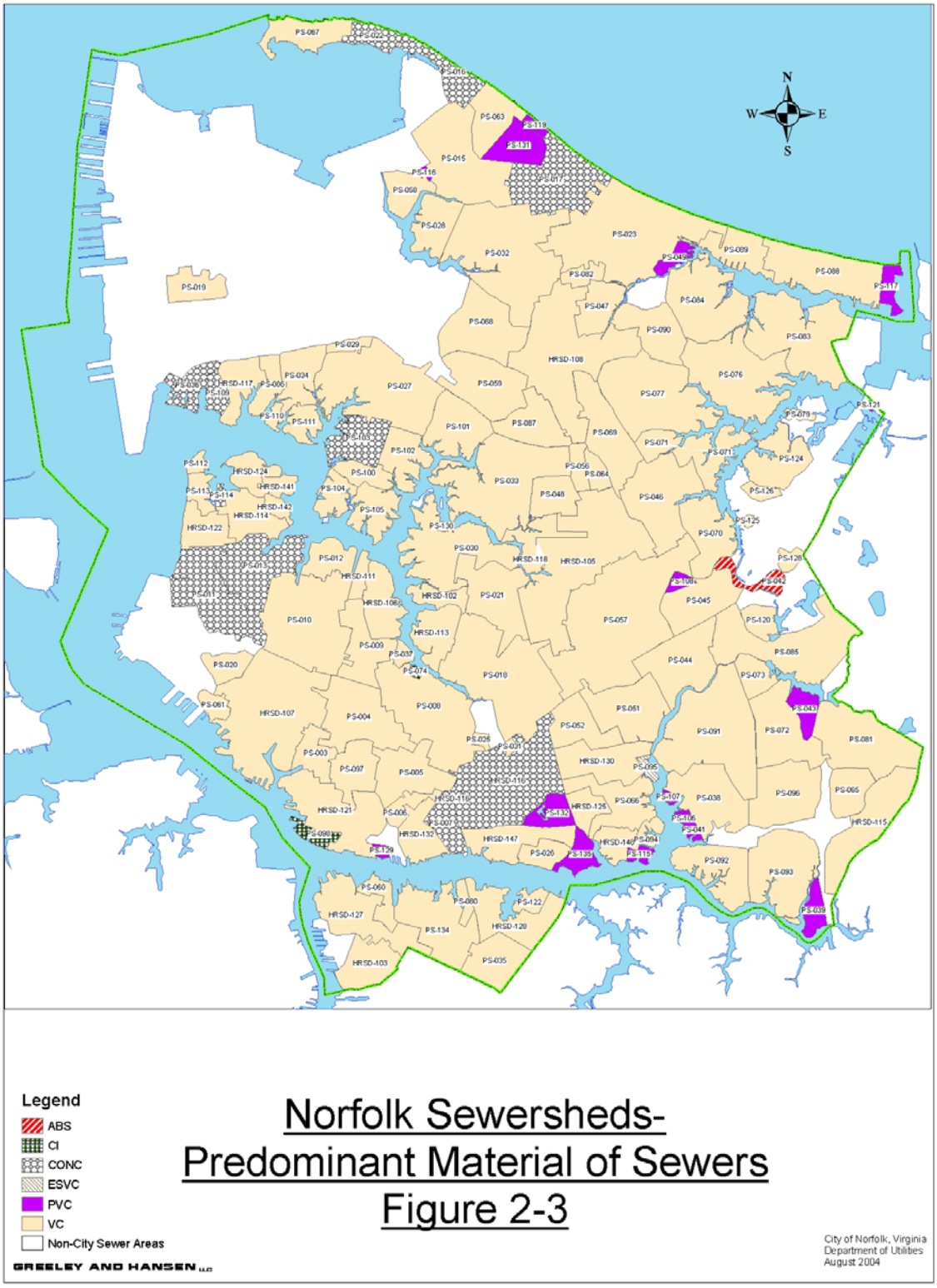


Figure 2-4
Schematic Example of Sewershed Project Areas

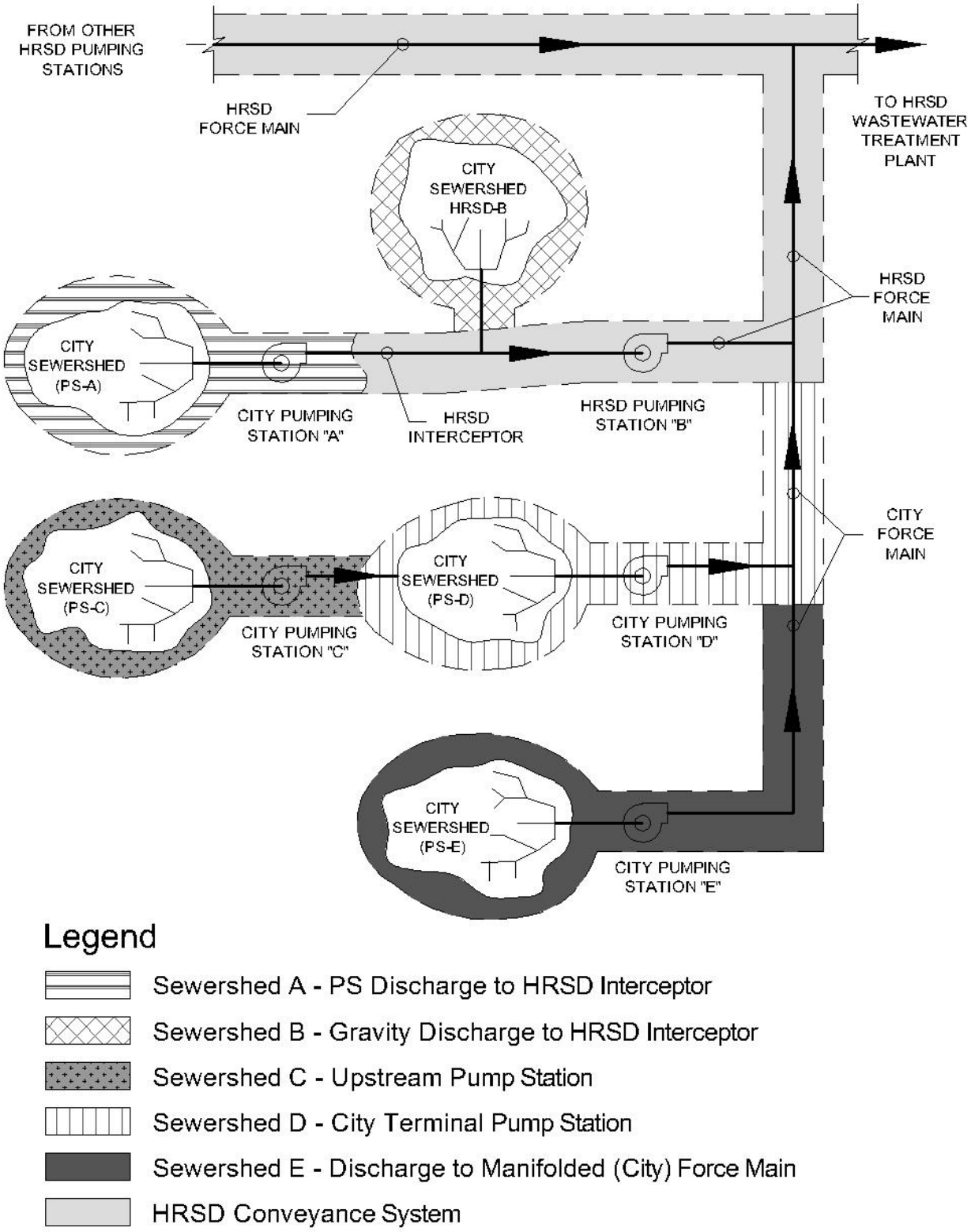


Figure 2-5
Pumping Station Evaluation Schematic

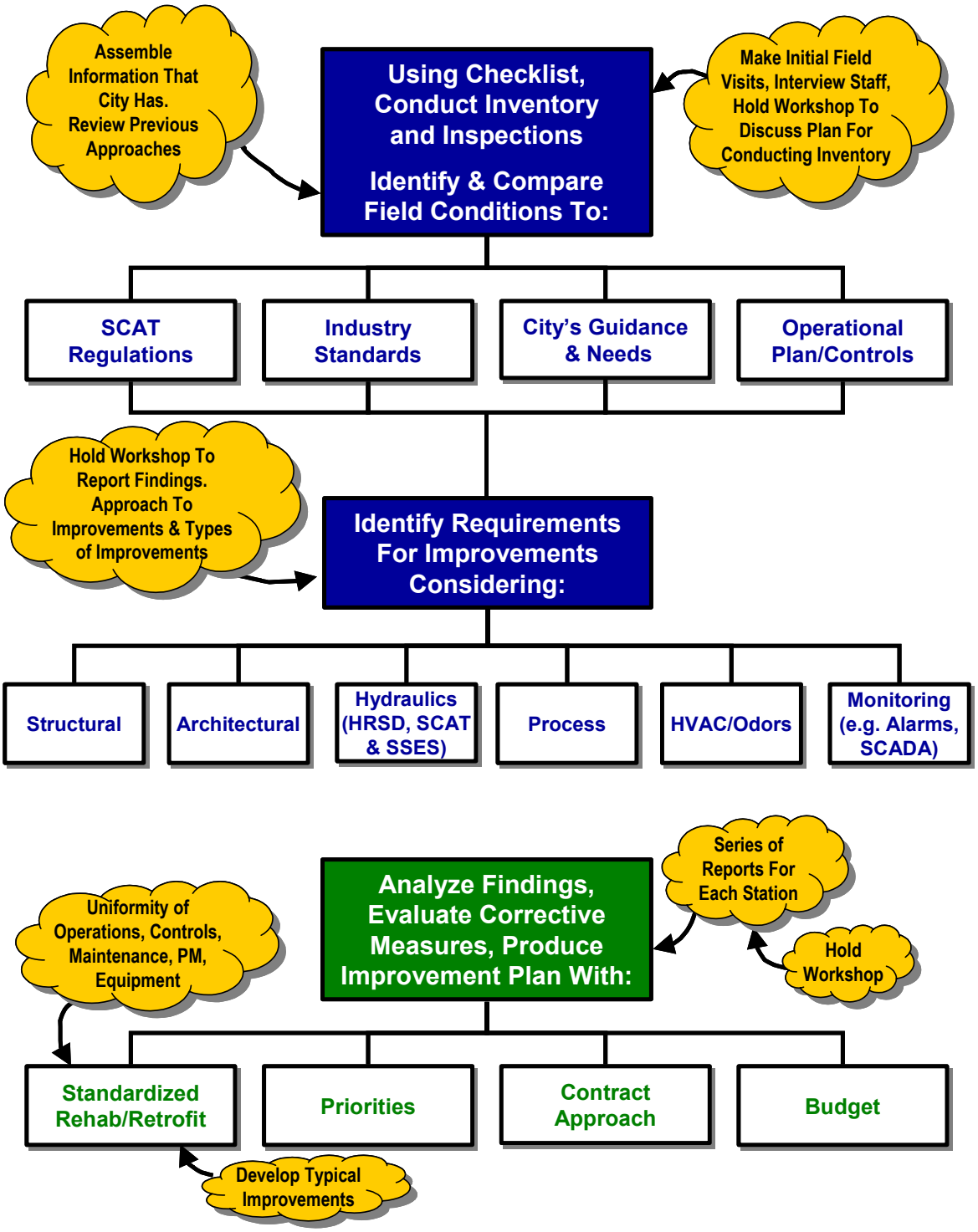
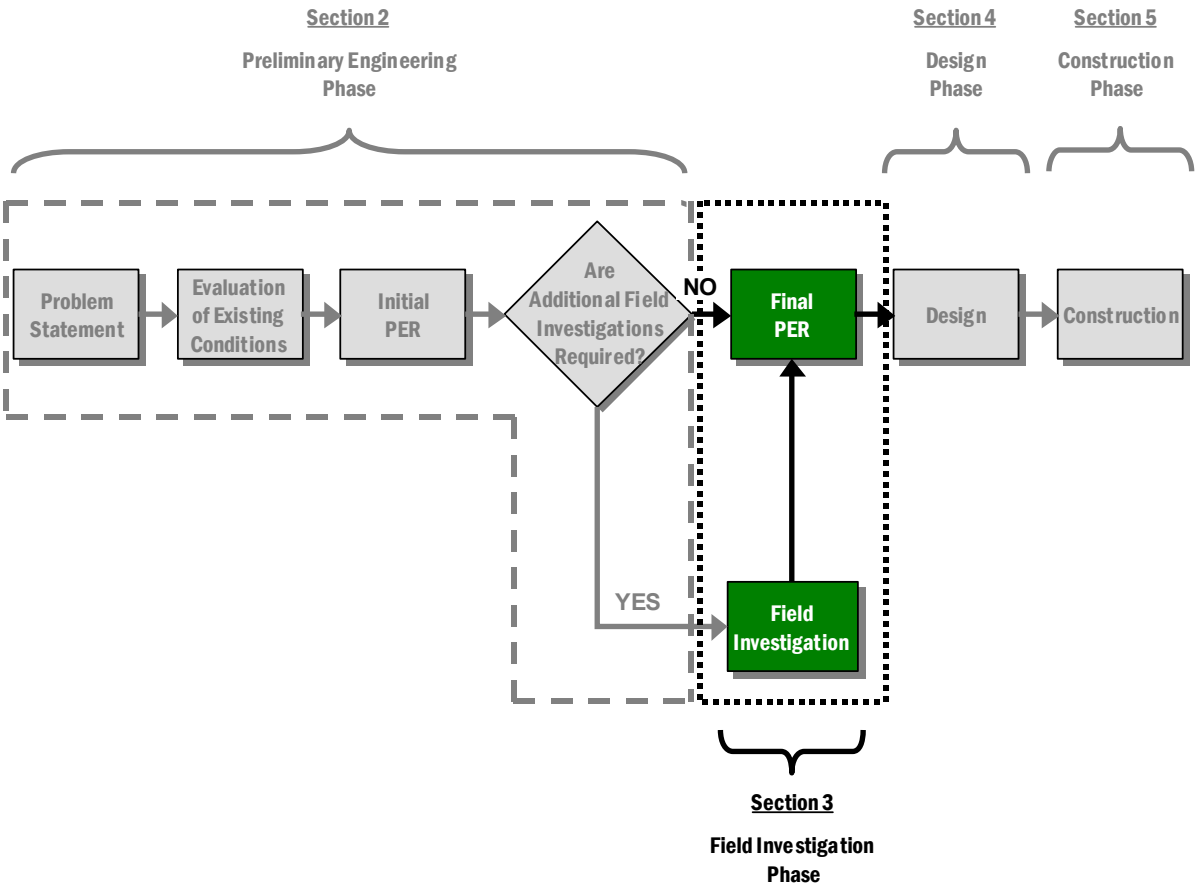


Figure 3-1
Field Investigation Phase



SECTION 3
FIELD INVESTIGATIONS

3.1 GENERAL APPROACH

Field investigations are performed after the Engineer's determination of their need has been documented in the Initial PER and approved by Utilities. The intent of these field investigations is to provide information required to recommend a remediation plan for the sewershed under study. As shown in Figure 3-1, field investigations normally follow the Initial PER with results incorporated into the Final PER. This section of the Manual provides guidance for conducting field investigations.

Figure 3-1
Field Investigation Phase

(Located at the beginning of this section)

3.1.1 Identification of Field Investigations

As outlined previously in this Manual, the City's typical approach to detailed sewershed investigations is to have the Engineer perform preliminary evaluations (including field reconnaissance) as a basis for ascertaining the need for and cost effectiveness of further detailed field investigations. For example, when the case can be clearly identified for replacement of certain reaches of sewer mains based on initial field reconnaissance, supplemental field investigations may not be cost effective or necessary. Conversely, there may be cases where the cost of further detailed investigations can potentially result in project cost savings for the City through better defining the required scope of upgrade work.

Information from the field investigations is used to evaluate sewershed conditions. Field investigations used in the sewershed investigation may include:

- Manhole Inspections - The purpose of a manhole inspection program is to obtain an assessment of conditions of the mainline sanitary sewer manholes and to identify sewer problems such as surcharging. The results of the manhole inspections also assist in the selection of locations for CCTV, smoke testing, and flow monitoring.
- Flow, Rainfall, and Groundwater Monitoring – The purpose of the flow-monitoring program is to determine the ADF generated in each sewershed and to estimate DWI and RDI/I. Rainfall and groundwater data are typically collected concurrently with flow monitoring.
- CCTV/Digital Imaging Inspection of Mainline Sewers – The purpose of the inspection program is to obtain a detailed understanding of the internal condition of the mainline sanitary sewer pipes.

- Smoke and/or Dye Testing – The purpose of the smoke testing program is to obtain information on the potential for inflow into the sanitary sewer system from stormwater runoff. Smoke testing is to be used judiciously since it requires an extensive public information program. Dye testing is typically used to locate and/or confirm suspected inflow sources such as storm-sanitary sewer cross-connections.
- Surveying or Inclinometer Evaluations – The primary purpose of these field investigations is to confirm existing City database information relating to negative slope or critical slope areas in the system and to determine the extent of sags or other vertical alignment problems in the sewer mains. In addition, there are topographic property and other surveying requirements for either pumping stations or collection system projects.
- Pumping Station Inspection – The purpose of these field investigations is to determine the existing condition of the pumping station.

A detailed discussion of the different types of field investigation is presented below. Results of the investigations are to be documented and incorporated into the Final PER.

3.1.2 Data Needs Assessment

3.1.2.1 *General*

The Initial PER should recommend field investigations that are necessary to further assess the condition of the sanitary sewer system. In order to determine which types of field investigations would be needed to assess a range of issues, a matrix of data needs and typical associated issues was developed and is presented in Figure 3-2. This matrix should be used as general guidance; ultimately, the Engineer must determine and recommend the most appropriate field investigations based on specific characteristics of each sewershed.

Figure 3-2
Matrix of Data Needs

(Located at the end of this section)

3.1.2.2 *Data Interface with City IMS and GIS Requirements*

The information collected during the field investigations provides an indication of the existing conditions in the sanitary sewer system. This information is to be compiled by the Engineer for the primary purpose of conducting the detailed investigations, but is also to be provided to the City in a manner that will allow the City to utilize this data in the City's Hansen Information Management System (IMS). The collected information is integrated with the City's IMS and GIS systems for subsequent System evaluations. Utilities can also use this information to manage the System (e.g. record service requests, generate work orders, record intervals between services) and develop bases for preventive and predictive maintenance.

All data collected during the field investigation phase should be recorded and documented using standardized forms approved by Utilities or in Utilities' standardized format for ready input into the City IMS. Examples of forms for the field investigations and the CCTV protocol necessary for integrating with the IMS are discussed below.

3.1.3 Phased Approach to Field Investigations

The objective of the field investigative phase is to conduct cost effective evaluations that will provide an appropriate level of System information for making sound rehabilitative decisions. In many situations, a phased approach is advisable to control costs and yet provide the City with sound results to support the Engineer's recommendations.

The following approach and methodology is provided specifically for gravity system evaluations; however, a similar phased approach can be utilized for pumping station or force main projects.

3.1.3.1 *Approach*

Three levels of investigation have been developed to identify and isolate the worst conditions in the sewershed through a phased approach. The most common field investigations (sewer condition indicators) to be used in this phased approach and the relative magnitude of cost (per linear foot) of each are listed below:

Investigation Level	Sewer Condition Indicator	Relative Cost
I	Field Reconnaissance • Manhole Checks • PS & wet well evaluation • Critical location inspection • Interviews w/ O&M staff	Low
II	Limited Manhole Inspections Smoke/Dye testing Limited CCTV/Digital Imaging Inspection	Medium
III	Subbasin flow monitoring CCTV/Digital Imaging Inspection Manhole Inspections	High

3.1.3.2 *Methodology*

The condition indicators listed above may be used to evaluate and screen subbasins in the sewershed, to select subbasins where sewer upgrade work should be performed, and to determine the type and extent of rehabilitation required in the highest priority subbasins. The extent of the more costly field investigation methods such as CCTV/Digital Imaging inspection and flow monitoring can be determined (and optimized) based on the findings of the less costly methods. The field investigation techniques will be used in a phased, systematic manner as follows:

Level One (I) - The low relative cost sewer condition indicators will be used to determine which subbasins have the greatest potential for poor sewer conditions. Field reconnaissance would normally be conducted during the initial investigations in the Preliminary Engineering Phase. The locations for field reconnaissance would be based on existing condition reports (review of SSO history; sewer service call history; etc), review of SSES and prior reports, and review of Department (Engineering and Operations) information. Field reconnaissance would typically involve one or more days in the field investigating problem areas. Work, such as manhole checks to obtain an overview of manhole and sewer conditions, would not typically involve the detailed documentation required by Level II and Level III investigations. Subbasins with few significant issues could be eliminated from the sewer upgrade plan and the need for Level II and III investigations.

Level Two (II) - The objective of this level of field investigation is to further evaluate specific subbasins for potential sewer upgrade. Limited manhole inspections, smoke testing and limited CCTV can be used to confirm issues determined in the Level I assessment. It is estimated that 10% to 25% of the manholes and sewer reaches in some or all of the subbasins in the sewershed could be subject to Level II inspection.

Limited manhole inspections should be conducted to obtain information on manhole conditions and to observe sewer flow conditions, including indications of surcharged sewers. Based on the results of the Level I investigations, a sampling of manhole inspections will be conducted in subbasins with potentially more significant problems. Conditions noted in the Level II subbasin investigations that require upgrade will become part of the sewer upgrade plan.

Smoke and/or Dye testing may be conducted as part of the Level II evaluations. Although not a costly investigative method, due to the public involvement, smoke testing should only be used in areas of the sewershed where inflow sources are suspected. Prior to conducting any smoke testing the Engineer should coordinate with Utilities and other City agencies.

Limited CCTV inspections may also be used to make an assessment of suspected poor sewer conditions and areas that may have improperly installed linings.

The location and extent of Level III investigations will be based on the results of the limited manhole inspections, smoke testing, and limited CCTV inspections conducted in the Level II investigations.

Level Three (III) - Flow monitoring and additional CCTV and manhole inspections may be used to more completely determine the actual conditions within problem areas and to further evaluate the need for sewer upgrade. It is estimated that about 25% to 50% of the manholes and sewer reaches in some or all of the subbasins would be subject to Level III investigation. This information will be used to determine the location, type and extent of sewer upgrade necessary for the sewershed investigation project.

Flow monitoring is conducted to estimate DWI and RDI/I, to assist in determining those subbasins to be considered for more detailed CCTV work, and to determine the location, type and extent of sewer upgrade necessary. A flow monitoring program should be based on the System layout and the results of the Level I and II investigations and should be developed to determine overall sewershed flows and to characterize the subbasins flows.

3.1.3.3 *Summary of Phased Subbasin Investigation*

1. Lower cost field investigations, typically conducted during the field reconnaissance phase, will be used to select subbasin problem areas for further evaluation.
2. Medium cost field investigations will be used to further screen subbasin problem areas as candidates for upgrade needs based on field condition evaluations.
3. Higher cost field investigations will be used as appropriate to select subbasin problem areas requiring rehabilitation and to determine the location, type and extent of sewer upgrades.

This approach and methodology can be used for most sewershed investigations; however, in certain cases one or more of the field investigation levels may be eliminated based on particulars of a given sewershed such as the (small) size of the sewershed or early definition of sewer problems.

3.2 GRAVITY SEWER FIELD INVESTIGATIONS

3.2.1 Manhole Inspections

One of the most useful tools to determine the condition of a collection system is to perform and document inspections of manholes. Manholes (especially those constructed of brick and with little or no mortar or sealed coating on the inside) have the potential to allow large quantities of I/I to the collection system, especially during rain events. Some manhole lids are lower than the surrounding surface and can act as drains for storm water when streets are flooded during wet weather. Manhole inspections not only provide data pertinent to I/I control and structural condition evaluations, they also can demonstrate whether the connecting mainline sewers operate under full or surcharged conditions.

Utilities considers manholes confined spaces, and personnel entering manholes must follow established confined space entry (CSE) protocol. Confined space entries made by subcontracting personnel are required to follow the City's CSE permit system requirements and to have their own trained and certified personnel and equipment.

3.2.1.1 *Criteria for Selecting Manholes for Inspection*

The locations for manhole inspections should be selected based on the results from the Preliminary Engineering Phase. In general, manhole inspections should be conducted at representative and/or critical locations within the sewershed. Criteria for the selection of locations may include:

- Sewer system age and pipe materials.
- Location of upstream force main discharges.
- Distribution and frequency of SSOs.
- Sewershed characteristics such as land use and geographic location (e.g. proximity to bodies of water and high groundwater table).
- Reported historical problem areas.
- Frequency and location of service requests.
- Previous field investigations, including information from the Wastewater Division CCTV investigations conducted to support the mainline and houseline maintenance crews.

As mentioned above, manhole conditions may be symptomatic of mainline sewer pipe conditions; therefore, areas within the City that are suspected as having problems related to grease, surcharging, structural defects, sagging, collapsed sewers, and roots could be targeted for manhole inspections.

3.2.1.2 *Data Collection*

A topside manhole inspection should be completed to determine its overall structural condition. Inspections are generally conducted during daytime hours. Some areas with heavy traffic may require nighttime inspection. Also, manholes found to be surcharged during the daytime may need to be inspected during nighttime if lower flow permits. The City will assist the Engineer in opening any manholes that cannot be easily opened with a pick or similar opening device.

Each manhole has a unique number assigned by the City according to its relation to the City's Intersection drawings. The manhole identification number shall be used to identify each manhole inspection performed. Information shall be collected on the manhole cover, frame, adjustment rings, cone, steps, wall, bench and channel as well as connecting influent and effluent pipelines.

The Engineer is to ensure that all identifying information collected during manhole inspections is complete and in the correct format. Providing correct information is necessary to prevent discrepancies between the manhole inspection forms and the IMS and GIS database. The results of the inspection shall be noted on a Utilities standard *Manhole Inspection Form*, an example of which is included in Appendix F. Use of this standardized form is to allow interfacing with the Hansen IMS system and accordingly with the incorporated Hansen manhole condition rating system.

The physical data obtained at each manhole shall be compared to as-built data and existing mapping. Identified discrepancies shall be noted and reported to the City. As the manhole inspections are performed, Utilities shall be notified via facsimile or telephone of any conditions observed which warrant immediate attention.

3.2.2 Smoke and Dye Testing

Smoke testing and dye testing of mainline gravity sewers is useful in determining potential sources of RDI/I. In general, there are two types of sources that can be investigated:

- Direct connections such as:
    - Downspouts, area drains, driveway drains, stairwell drains, patio drains, and storm sewer inlets or ditches
    - Service lateral (houseline) holes, damaged cleanouts, cleanouts with missing caps, and
    - Cracked manhole frames and covers
- Indirect connections from storm sewers or ditches that require I/I to pass through soil seams

Smoke testing is performed by forcing a non-toxic, white smoke through a mainline sewer with the aid of smoke blower positioned over an open manhole. Plugs and/or sandbags are used to isolate pipes in manholes where smoke testing defect data is not to be collected. In the case of dye testing, a dye is injected into drop inlets or other potential inflow sources and observations made at each location for evidence of cross connections to the sanitary sewer.

All smoke testing shall be closely coordinated with Utilities and other City agencies; prior to initiating smoke testing, property owners, civic leagues and police and fire officials shall be notified. As a minimum, such notification should describe the purpose and procedures of smoke testing, provide answers to frequently asked questions including schedule and observations, and indicate contact numbers for additional questions.

3.2.2.1 *Determining Locations for Smoke Testing and Dye Testing in Each Sewershed*

Smoke testing is typically conducted where there is a greater potential for inflow based on prior information such O&M experience, field reconnaissance, limited (Level II) manhole or CCTV inspections, or flow monitoring.

Dye testing is more appropriate for inflow sources such as downspouts, area drains, patio drains, window well drains, stairwell drains and driveway drains since trapped building service laterals or clogged drains may not allow detection through smoke testing. Smoke and dye testing are typically done on a limited scale, and can be part of a cost effective phased approach in identifying and reducing inflow in a sewershed.

3.2.2.2 *Data Collection*

For both smoke and dye testing, visual inspections are performed in the immediate area being tested. Smoke test conditions are considered to be adequate when smoke is observed exhausting from the building vent at the end of the smoke test sewer reach. The locations of smoke exiting from System defects shall be recorded by address and captured by color digital photography.

Observations from smoke testing are to be recorded on a Utilities standard *Smoke Testing Observation Form,* an example of which is included in Appendix F. Specific defect information recorded on the form includes defect type, type of surface cover, estimate of surface runoff in gallons per minute, location referenced to the mainline sewer, address, and photograph references.

Dye test observations are conducted by visual inspection of suspected downstream manholes or in some cases the pumping station wet well. Pumping station wet well levels may need to be lowered for proper observation under certain flow conditions.

3.2.3 CCTV/Digital Imaging Inspection

The purpose of a CCTV/Digital Imaging inspection program is to obtain an assessment of the internal condition of the mainline sanitary sewer pipes. The Engineer shall provide services capable of gathering still and video images inside wastewater pipes, indexing the images, allowing review and ranking of pipe conditions, and generating databases and reports necessary for assessing the condition of the sewers in question. Mainline sewers to be inspected should first be cleaned and then visually inspected. All television inspection work will be performed in accordance with Section 811R of the Hampton Roads Planning District Commission Regional Construction Standards.

3.2.3.1 *Criteria for Selecting Sewers to be CCTV/Digital Image Inspected*

The CCTV/Digital Image locations for inspection should be selected based on the Preliminary Engineering Assessment and the phased approach to field investigation previously discussed. Areas in the sewershed that are known to have problems related to grease, surcharging, structural defects, sagging, collapsed sewers, and roots should be targeted. In order to maximize the benefits of the inspection program, subbasins where inspections have been previously conducted or where the need for rehabilitation has otherwise been identified should be excluded.

3.2.3.2 *Data Collection*

Project information should include: project name, inspection number, contract number, upstream and downstream manhole numbers, operator names, inspection direction and client name. Time, date, footage and VCR counter reading information will be provided by the software and be recorded in each inspection assessment. If an inclinometer is used during the CCTV/Digital Image inspection, percent grade of the pipe will be recorded.

Recording as MPEG files shall be provided as well as CD's and/or DVD's of the CCTV/Digital Image inspection. Complete, detailed summary reports, including Overview Report, Defect Reports and Plot View Report, are to be provided in hard copy and as HTML files.

The Engineer shall provide a system of information collection that is compatible with and easily integrated by the Utilities' IMS. The CCTV/Digital Imaging software shall be NASSCO PACP© Standard Database compatible and must also be Neztek certified for transferring databases to Hansen IMS systems. The software must have the ability to export data to the City of Norfolk's Hansen IMS system from the CCTV/Digital Imaging inspection software. The Engineer is accordingly to use the condition rating system incorporated into the NASSCO certified software as part of the sewershed evaluation process.

3.3 PUMPING STATIONS

Pumping station issues can range from grease problems to critical locations near a tributary stream or river. Examples of problems that were identified in the City's SSES evaluation of pumping stations in Norfolk's System included:

- **Grease problems:** Rainfall tends to flush solids out of the sewers into the pumping station wet wells. Some pumping stations do not have provisions for grease disposal.
- **High impeller wear:** Pumping stations in areas where sandy soil enters the sewers through I/I pathways may have impeller wear problems.
- **Mechanical problems:** Major mechanical problems are not widespread due to Utilities ongoing maintenance management system. However, any potential upgrade project should fully evaluate both main and ancillary items.

- **Sand and grit in wet wells:** This can be an indication of I/I problems in the gravity sewer system.
- **Small wet well:** A small wet well can, in some instances, contribute to sewer backups and overflows and can also contribute to shortened lifetime of mechanical equipment due to more frequent pump cycling.
- **Influent sewer surcharging:** High wet well operating levels at some pumping stations may be the reason for backups into the gravity sewer system. The operating level of wet wells should be discussed in detail with Utilities.
- **Proximity to reservoirs:** Pumping stations located within the reservoir drainage areas are always given special attention. A failure of these pumping stations could cause an overflow and result in possible contamination to the City's water supply.
- **Wastewater flow from the water treatment plant:** Chemical waste (lime-based) from the plant may cause pumping and pipe scaling problems.

Investigations of pumping stations should be conducted in a consistent manner. An Inspection Checklist is provided in Appendix F to provide uniformity in assessing the condition and component elements of the pumping station. The Engineer should visually inspect the various features of the pumping station while documenting the information on the Pumping Station Inspection Form. Some of the key information to be obtained during the inspection is outlined below.

Building Condition Visually inspect the interior, exterior and roof of the building for physical or structural problems. Measure and record the building length and width (and compare against as-builts), the construction material for the exterior walls and the roofing system. Assess the structural condition of the building elements with a "Good", "Fair" and "Poor" rating system.

Pumps and Motors From the manufacture's data plates and any up-to-date maintenance information. Record the pumps head in feet, the capacity in gallons per minute and the impeller diameter in inches for the pump and record the horsepower and listed RPM for the motor. Observe the pump and motor for vibrations, sounds, temperature and odor. The operating logs should be observed as well as consulting with the operations staff to determine under what conditions and how long all pumps would operate at the same time.

Wet Well The engineer should inspect the wet well in a dewatered state to insure a complete and proper visual inspection. The walls should be observed for coating conditions, spalling or softness of concrete, erosion of concrete and the condition of bottom fillets.

As stated in the City's Standard Design Criteria, Section 1.2.08.1, "The effective capacity of the wet well should be such that one pump will run continuously at least five (5) minutes during a thirty (30) minute period of minimum flow at design flow conditions and there will be no more than five (5) pump starts per pump in one hour." The Engineer should observe the time of day, flow conditions, and the actual on and off time of several pump cycles. The pump discharge should be observed at the downstream discharge manhole.

Corrosion of Ancillary Equipment While the wet well is in a dewatered state and after cleaning, the Engineer should inspect the ventilation system ducts and fans, access hatch, interior railing, access ladder and platforms, pump control system, pump rails, and interior piping for corrosion.

Dry Well The Engineer shall visually inspect the dry well for structural conditions that would be of concern. He shall also observe the equipment removal system and coating systems.

Piping Visually inspect the piping, valves (check, isolation, surge relief and air relief) and other fittings for corrosion, leakage and proper operation. The piping condition should be evaluated in view of the need for replacement; and all suction and discharge piping should be evaluated for velocities at both present and future flow rates.

Emergency Generator/Pump The Engineer should have the generator/pump started to observe its operation, noting excessive noise, dark exhaust, and ease of generator/pump starting.

3.4 FORCE MAINS

Force main inspections should only be conducted if the preliminary engineering assessment indicates a history of failures or other circumstances, such as the need to extend the force main or to increase the capacity. Included in any inspections shall be air vents, mainline valves and other ancillary items.

3.5 FLOW, RAINFALL AND GROUNDWATER MONITORING

3.5.1 Purpose and Objectives

Flow monitoring should be conducted to characterize the flow rates and flow patterns and to determine locations and quantities of I/I in a sewershed. More specifically, the general objectives of a flow-monitoring program for a particular sewershed are as follows:

- Collect representative flow data for the sewershed and/or reaches for the specific project
- Obtain data for dry and wet weather periods
- Observe conditions that are a reflection of the overall condition and operations of the sewershed
- Correlate dry weather infiltration with collection system age and materials
- Correlate increases in RDI/I with rainfall events
- Provide actual field flow data to allow Utilities to check reasonableness of flows using the System hydraulic model

3.5.2 Approach

The Engineer shall provide, install, and maintain open channel flow meters, at an appropriate, minimum number of gravity sewer locations, for a one-month (minimum) flow monitoring period. Multiple meters may be required at a single manhole location due to collection system configuration and additional (monthly) time period extensions may be required to include wet weather. For each meter, the Engineer is to provide full service installation, on-going service, calibration and maintenance, as well as a full range of data collection, reporting and analysis for the monitoring period. Support services include line cleaning at time of installation, preparation of traffic control plans and implementation of traffic control measures in coordination with the City.

The Engineer shall comply with all applicable confined space entry requirements whenever entering the collection system.

3.5.3 General Requirements:

3.5.3.1 *Scope*

Flow performance information will help characterize the capacity of selected sewersheds during dry and wet weather flow conditions. The Engineer shall evaluate DWI and RDI/I in response to specific storm events, and when applicable, make recommendations to target areas for further investigation.

3.5.3.2 *Flow Monitoring Equipment*

Equipment shall consist of an open channel flow monitor(s) installed in the sewer manhole functioning as a data logger, communication device and sensor command unit and a rain gauge at a suitable location. All equipment must be suitable for installation in the hazardous locations of manholes or wet wells and shall be capable of recording in both low flow and surcharged conditions.

3.5.3.3 *Data Collection*

Flow and rainfall information will be collected (downloaded) at periodic intervals (minimum of weekly) for the duration of the monitoring period. Data logging of the sensor readings shall be for not greater than 15-minute intervals. The flow monitoring results and raw data shall be presented electronically to the City via CD and hard copy in Microsoft Office (Word & Excel) format.

3.5.3.4 *Rainfall Gauging*

All flow monitoring locations will be assigned at least one rain gauge for purposes of assessing the impact of rainfall on flows. If the Engineer determines, subject to the City's concurrence, that the City's rain gauge network is appropriate for project purposes, the City will provide rainfall data to the Engineer. Otherwise, the Engineer will provide a portable rain gauge(s) including all data collection, compilation, analysis and maintenance of equipment.

3.5.3.5 *Groundwater Monitoring*

At least one groundwater monitoring piezometer, for purposes of assessing the impact of groundwater on flows, shall be provided for each rainfall gauging location or for each project. The Engineer shall check the installation and record such data on the same frequency as the flow monitoring field checks. The Engineer shall submit to Utilities a proposed construction detail for such groundwater monitoring piezometer at such time as the flow monitoring plan is submitted for review.

3.5.3.6 *Flow Monitoring Report*

The Engineer shall provide to the City a report that presents the data collected during the flow-monitoring period. The report shall provide a narrative summary of observed flow conditions and be supported by a graphical and tabular presentation of flow depth, velocity and quantity data, along with rainfall data. Each flow monitoring location is to include the following minimum information in the report:

- Commentary - A brief narrative summary of general hydraulic conditions recorded and maintenance performed during the flow monitoring period
- Graphical Representation of data – A graphical plot (scatter graph) of flow depth versus velocity data recorded during the flow monitoring period and a graphical time-series plot (hydrograph) of hourly average flow depth, velocity and quantity data, as well as associated recorded rainfall data.
- Tabular Data – A tabulation of daily average, maximum and minimum flow depth, velocity, and quantity data recorded during the flow monitoring period. Summary information should also be included for each consecutive seven-day period of the flow-monitoring period.
- Monitoring Data – Instantaneous flow depth, velocity and quantity data in Microsoft Excel format
- Installation Report – A summary of the installation details associated with each meter location, including a sketch of the manhole details and identifying manhole information.

In addition, the Engineer shall provide the City with biweekly status reports including compiled raw data, as a minimum.

3.5.3.7 *Data Analysis*

The Engineer shall evaluate results of the flow and rainfall monitoring under both wet and dry weather conditions and attempt to obtain at least two wet weather rainfall events with greater than 0.5-inches of locally recorded rainfall. The flow monitoring analysis shall include the following items for each flow monitor location:

- Dry weather characterization (graphical and tabular) of conditions observed during weekday and weekend periods, summarized as time-series hydrograph data for the average diurnal flow quantities.
- Wet weather characterization (graphical and tabular) of conditions observed during specific wet weather events observed during the flow monitoring period, summarized as time-series hydrograph data, and comparing observed flow quantities to the average diurnal flow quantities.
- Determination of DWI for the sewershed and/or subbasins
- Determination of RDI/I for each wet weather event. RDI/I shall be expressed as the percentage of rainfall on the sewer basin flow monitored that entered the sewer system.
- Tabular summary of sewer capacity indicators relating average dry weather, peak dry weather and peak wet weather flows to pipeline capacity, including frequency of surcharging conditions.
- Summary and recommendations for prioritization of system needs based on flow monitoring results as well as identification of further investigative needs.

3.6 SURVEYS

Types of field surveys that can provide important evaluation and design information for the sewershed investigation include:

- Easement or Boundary Survey
- Topographic Survey
- Invert Elevation Confirmation

Because there are several different benchmark datum in the Norfolk area, the Engineer must carefully evaluate all field, design and as-built information to insure that all elevations are on the same datum. The following is a definition of the City of Norfolk Datum compared to the North American Vertical Datum of 1988 (NAVD 88) and 29 (adjustment of 1958) and the NOAA Tidal. The lower elevation of the MLW is reportedly explained by the City of Norfolk datum being based on a tidal station at Colonna's shipyard in the early 1890s.

	City of Norfolk	NAVD 88 (92)	NGVD 29 (59)	NOAA Tidal
Mean Higher High Water	102.77	0.81	2.02	2.80
NAVD 88	101.96	0.00	1.21	1.99
Mean Tide Level	101.33	-0.63	0.58	1.36
NGVD 29	100.75	-1.21	0.00	0.78
Mean Lower Low Water	99.97	-1.99	-0.78	0.00
City of Norfolk, 99.00=MLW	99.00	-2.96	-1.75	-0.97

Current elevations on benchmark monuments in the City of Norfolk network are based on the NAVD 88 (92) datum.

The Engineer must insure that all proposed pumping station construction, station ingress/egress and sewer line and force main alignments will have appropriate easements and property setbacks. Tax map and title searches may be necessary when new facilities are proposed to identify property issues. Whenever possible, utilities are to be constructed within the public right-of-way. Otherwise, water or sewer easements shall be acquired, dedicated and recorded solely for the benefit of Utilities. Easement boundaries shall clearly be distinguished from (fee simple) property bounds and shall be shown accordingly on the site plan. Additional detailed information on easement requirements can be found in the City's *Standard Design Criteria Manual.*

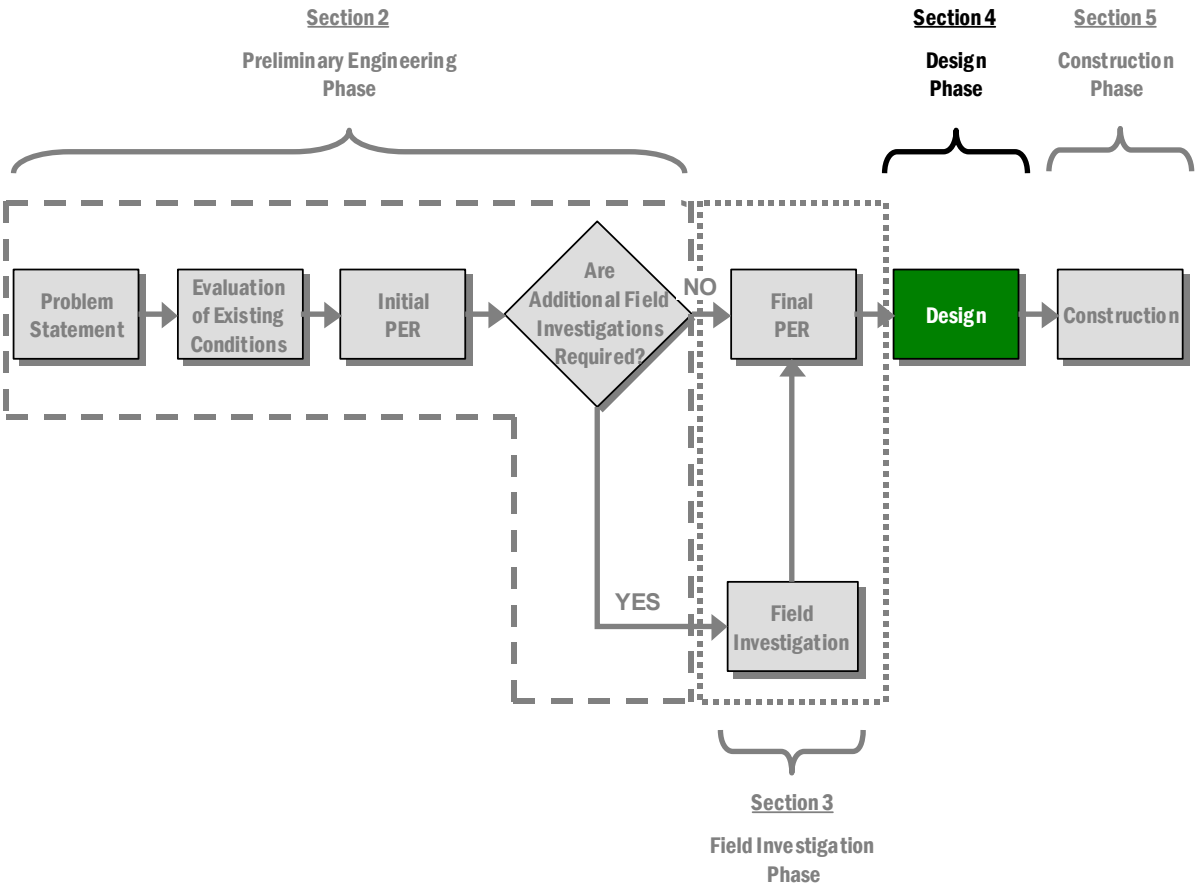
3.7 FINAL PER

Upon completion of the field investigations and/or upon receipt of any comments from Utilities on the Initial PER, the Engineer shall revise the PER through incorporation of field investigation results, revised alternative analyses, and revisions to the findings, conclusions, recommendations and conceptual design. This document shall represent a Final PER and shall incorporate the format and content as outlined previously in Section 2 of this guidance Manual. Revised costs estimates shall also be provided based on the above-mentioned information.

Figure 3-2
Matrix of Data Needs

SEWER SYSTEM ISSUES	Record Review	Inclinometer	CCTV Mainline	CCTV Lateral	Manhole Inspection	Smoke Testing	Dye Testing	Hydraulic Modeling	Flow Monitoring	Groundwater Monitoring	Rainfall Monitoring	Topographic Survey	Easement/Boundary Survey	PS Instrumentation Assessment	PS Pump Run-Time Assessment	PS Wet Well Fill-Time Assessment	PS Wet Well Structural Assessment	Pumping Station Draw-down tests
	INVESTIGATIONS																	
HOUSELINES																		
Capacity																		
Evidence of I/I				●		●												
SSOs	●			●														
Surcharging	●			●														
Structural Condition																		
Stability of Material				●														
Age	●			●														
Maintenance																		
Roots	●	●		●														
Grease	●	●		●														
MAINLINES																		
Capacity																		
Evidence of I/I			●	●		●	●	●	●	●	●							
SSOs	●	●	●	●	●			●	●	●	●							
Surcharging	●	●	●	●	●													
Structural Condition																		
Defective Liner	●		●															
Age	●	●	●															
Stability of Material/Collapse	●		●															
Sagging/Misalignment		●	●					●										
Maintenance																		
Roots	●	●	●															
Grease	●	●	●															
Orientation																		
Backyard	●											●	●					
Reverse Slopes	●		●									●						
MANHOLES																		
Capacity																		
Evidence of I/I	●				●				●	●	●							
SSOs	●				●			●	●	●	●							
Surcharging	●				●			●	●	●	●							
Structural Condition																		
Stability of Material	●				●													
Age	●				●													
Maintenance																		
Roots	●				●													
Grease	●	●			●													
Orientation																		
Backyard	●											●	●					
FORCE MAINS																		
Capacity	●							●						●	●	●	●	●
Structural Condition	●																	
PUMPING STATIONS																		
Pumps																		
Capacity	●							●	●		●			●	●	●	●	●
Operation	●							●	●		●			●	●	●	●	●
Wet Wells																		
Capacity	●								●		●			●	●	●		●
Structural Condition	●	●															●	

Figure 4-1
Design Phase



SECTION 4
FINAL DESIGN

4.1 DESIGN PROCESS OVERVIEW

4.1.1 General

The final design phase of a sewershed upgrade project represents the Engineer's development of a detailed project design and biddable construction documents. This will allow a Contractor to properly construct (or rehabilitate) the sewerage facilities in accordance with the alternative recommended by the Preliminary Engineering Report. The product of the Final Design is a set of Contract Documents consisting of plans (Drawings) and specifications (Project Manual).

As shown in Figure 4-1, this work follows acceptance of the PER by the City and progresses through completion of the final design, including bid period assistance and contract award recommendations to the City. In addition to the Final Design (100%) submission, the City requires progress design submissions by the Engineer at the 50% and the 90% intermediate milestones. This section of the Manual outlines general requirements for the design submissions and provides information on cost estimating procedures to be used for all sewershed projects.

Figure 4-1
Design Phase

(Located at the beginning of this section)

4.1.2 Standard Design Criteria Manual

While this ***Sewershed Investigation Guidance Manual*** provides Engineers with City guidance for the preliminary analysis and the project's procedural overview, technical design requirements of sewer system projects are outlined separately in the City's ***Standard Design Criteria Manual***. This design criteria guidance document includes:

- General and technical design information on:
  - Sewage Pumping Stations
  - Collection Systems
  - Force Mains
  - Water Mains
- Contract Drawing Requirements, including the City's CADD standards
- Easement Requirements

These technical design criteria apply equally to both the Preliminary and Final Design phases of sewershed upgrade projects. The Engineer should utilize both the ***Standard Design Criteria Manual*** and this guidance Manual to insure consistent and appropriate sewer system designs for the City of Norfolk.

4.1.3 Fifty Percent (50%) Design Submission

The fifty percent design submission represents completion of the preliminary design and progress towards the final design to allow for appropriate review of the design drawings by Utilities. The 50% submittal for pumping station upgrade projects shall include all plans and sections, mechanical layouts, site plan, utilities locations, construction phasing, electrical single line drawings, major instrumentation schematics, clarifying details, etc. This submittal for sewer and force main drawings should include all major plans and profiles, clarifying details including connection details, existing utilities, construction phasing and other aspects, which the Engineer deems necessary to obtain City input and review. This submission shall also be in accordance with requirements of, and be submitted for approval to, the City's Site Plan Review Committee. The 50% design submission will include a cost estimate.

4.1.4 Ninety Percent (90%) Design Submission

The ninety percent design submission represents the substantial completion of the final design for review by the City of the Project Manual and the Drawings. The draft Project Manual shall be submitted including all City standard documentation (front-end documents and forms) as well as all applicable HRPDC specification references, representing a complete package for review. The drawings shall be a complete set of plans including revisions to the 50% submission as well as such elements as erosion control, final electrical and instrumentation drawings, and details incorporating the final design for all of drawings. The collection system plans shall be complete including all details of connections, phasing, abandonment details, reconnection details and utility relocations as appropriate. The 90% submission will include an updated cost estimate.

4.1.5 Final Design (100%) Submission

The final design documents shall represent the complete package, incorporating all Utilities comments, shall be in accordance with City and SCAT checklists for final submissions, and shall be for approval by the City, including the City's Site Plan Review Committee. The Engineer shall provide an original (mylar drawing cover sheet for City signatures) and the required number of copies of the Final Design for approvals and/or for bidding purposes of the City.

4.1.6 Bid Assistance and Recommendations for Award

The Engineer shall provide assistance during the bidding period as required for response to inquiries by Contractors, clarifications and any development of addenda. The Engineer shall also be responsible for reviewing the bids, compiling a bid tabulation and making a recommendation for award to the Department of Utilities.

4.2 CONTRACT DOCUMENTS

4.2.1 Project Manual

The Project Manual, along with the Contract Drawings, represents the complete set of Contract Documents necessary for the bidding of City sewershed projects. The Project Manual consists of two types of information:

- Information describing the requirements for bidding, and
- Information that becomes part of the contract documents upon the execution of the construction contract.

The City has adopted "front end" documents which are revisions to the HRPDC Standards (Regional Construction Standards, latest edition) and that are to be utilized by the Engineer for all projects. The Engineer should review the City's "front end" specifications and modify them as appropriate for the specific project.

The City has also adopted "technical specifications" following the HRPDC Regional Standards. These HRPDC technical specifications are to be supplemented by the most current edition in use by the City of "THE CITY OF NORFOLK MODIFICATIONS TO HRPDC REGIONAL STANDARDS" developed by Utilities. These construction specifications are outlined in the City's Standard Design Criteria Manual and are periodically updated.

In certain cases, the City's standard specifications may be too general in nature for the specific project or the needs of the project may justify a deviation from these standards. In these cases the Engineer must develop supplemental technical specifications. The Engineer is responsible for any and all supplemental technical specifications, which must be approved by the City.

An example of one such situation that requires special considerations is a project for which there is a potential for state or federal funding. In these cases the Engineer is responsible for inclusion of all appropriate Virginia Revolving Loan Fund or other funding contract requirements.

The material included in the Project Manual should follow the following format:

- Title Page
- Table of Contents
- Addenda (If bound in Project Manual)
- Invitation to Bid
- Instructions to Bidders
- Proposal
- Escrow Agreement
- Contract
- Performance Bond

- Payment Bond
- Special Provisions
    - Sections 1 through 18
- Appendices

4.2.2 Drawings

Specific requirements of the City for design drawings are outlined in the City's ***Standard Design Criteria Manual***.

4.3 COST ESTIMATING

4.3.1 General

This information is intended to provide guidance on the preparation of an "Engineer's Estimate of Costs" for City of Norfolk Sewer Projects. This guidance provides information on estimating techniques, project and life cycle costs, the appropriate level of costing, and the format for cost estimates for the City sewer system projects. The Engineer's should provide an opinion of probable construction cost (cost estimate) based on knowledge, experience and sound judgment. Construction cost estimates will initially be developed during the PER. It is expected that the Engineer will produce a design in adherence with the City's CIP. The Engineer shall promptly inform the City if any deviation from the original estimated cost is identified and is to provide a justification and evaluation of why the construction costs are different (higher or lower).

4.3.2 Estimating Techniques

Various publications provide construction cost data. However, these publications present the data in different forms. Even within a given publication, the cost data can include overhead and profit in one part and not include it in another part. Therefore, it is important that each publication's instructions on the use of its cost data be thoroughly read and understood before using the publication.

Every effort should be made to obtain written quotations from manufacturers, manufacturers' representatives, suppliers and others, particularly in the case of major equipment items. Each quotation should contain a detailed description of the materials or equipment, with accessories, to which the price applies and a recommendation that those materials or equipment are appropriate for the intended application. These organizations can also be a resource for other cost estimating data, such as the labor types and hours needed to install their materials or equipment.

When preparing an estimate, cost estimating calculations and supporting quotations and cost data should be organized and grouped by topic. For example, all the calculations and data pertaining to a given set of pumps should be kept together and not mixed with calculations and data for other materials or equipment.

Cost components and cost totals should be rounded, generally upward to be conservative, to some nominal values. Examples would be:

$X,X00
$XX,000
$XXX,000
$X,XX0,000
$XX,XX0,000

The effects of inflation or escalation need to be taken into account because published cost data and quotations are typically applicable to a specific point in time or time period. The Engineer should escalate cost information to the midpoint of the construction period. The Engineering News Record Construction Cost Index (ENR - CCI) value or another generally accepted cost index value that applies to the estimate should be indicated on the document transmitting the estimate to the City. Use the ENR - CCI (or other index) that is in effect at the time the estimate is prepared. If the estimate is escalated to allow for inflation, indicate the amount of escalation included, if significant.

4.3.3 Project Costs

Project costs are a reflection of total costs for a project as opposed to *construction costs* that represent only the cost of construction or the contractors bid price. The types of additional costs factored into project costs include:

- Preliminary Engineering
- Field Investigations
- Final Design
- Contract Administration
- Construction Management
- Construction Inspection
- Administrative & Legal
- Project Contingencies
- Capitalized Interest

For purposes of preliminary cost estimating the City uses an approximate capital cost to construction cost factor of 1.6 for a typical capital improvement project for the City of Norfolk. However, this project cost adjustment factor should be reevaluated if other specific factors, such as legal costs or financing costs, are believed to uniquely affect the project. The engineer shall, in all instances, clearly identify whether the cost information provided is for "Construction Costs" or for "Project Costs".

4.3.4 Life Cycle Costs

In addition to the consideration of first time capital costs for sewer infrastructure, the alternatives analysis and preliminary engineering phase should involve evaluation of annualized O&M costs of the system. Such O&M costs would include electricity, periodic station inspection and maintenance, and other related costs such as instrumentation. These costs should all be evaluated by comparing annual O&M costs over a twenty-year life cycle along with the project costs on a present worth basis in the alternative analysis.

4.3.5 Level of Estimate

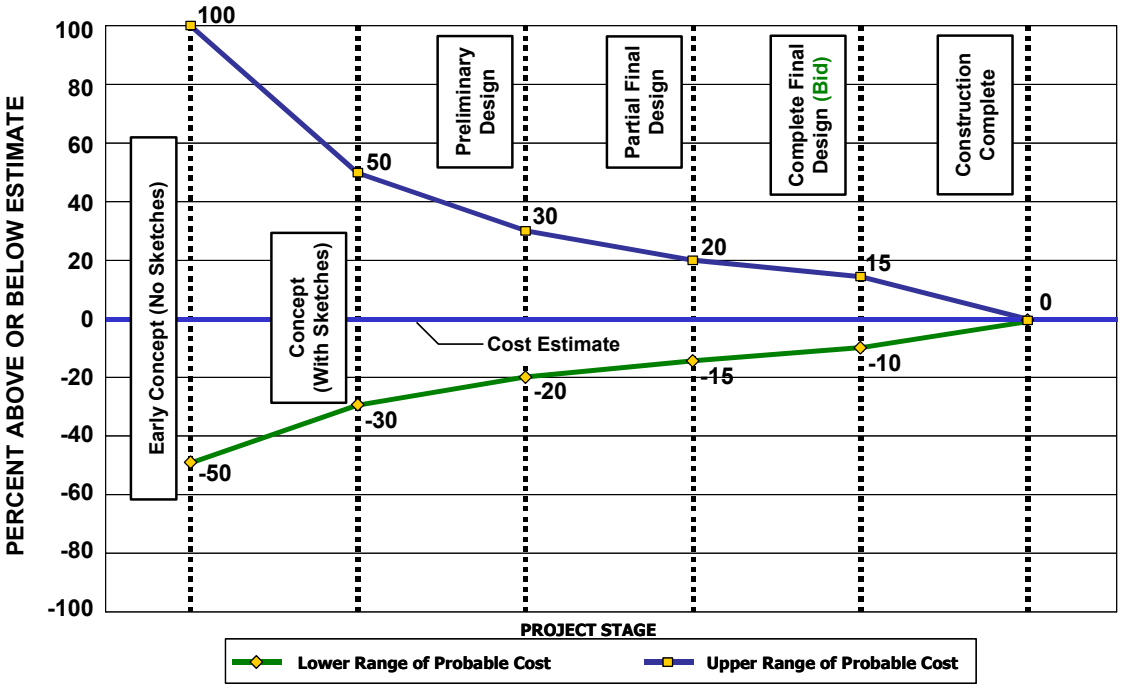
The Engineer should select the appropriate level of cost estimating based upon the extent of engineering effort and design completed at the time of the estimate. There are various levels of cost estimates defined by the Association for the Advancement of Cost Engineering (AACE), and for the City's Sewershed Investigation projects, it is expected that the Engineer will develop cost estimates in accordance with the following schedule:

Table 4-1
AACE Cost Estimates

Level of Cost Estimating			
Type	**AACE Class**	**Level of Project Definition, %**	**City of Norfolk Submissions**
Feasibility	5	0 –2	-
Conceptual	4	1 –15	-
Preliminary Design	3	10 – 40	Initial & Revised PER
Intermediate Design	2	30 – 70	50% Design
Final Design	1	50 – 100	90% Design, Final

Based on these definitions of project completion level, there are recognized margins for cost estimating accuracy that become more accurate with the advancing of the design development phase. This cost estimating accuracy is presented in the following Figure 4-2 (AACE Curve).

Figure 4-2
AACE Curve



Although the AACE guidelines provide information on typical cost estimating accuracies, the Engineer must consider other factors in the development of the cost estimate. Such other factors may include:

- Project Uniqueness – Are there precedents for the project work elements in this region?
- Quantity Values – Are the quantity take offs approximate or detailed and has an allowance been factored in for unforeseen circumstances?
- Quality of Cost Data – To what extent is the data general industry pricing versus project specific pricing?
- Market Conditions – Could the timing or abundance of other local construction projects affect the pricing locally?
- Scope of Project – Is the project scoped and sized to interest Contractors with an economy of scale?
- Inflationary Impact – What is the timing of the bidding of the project and how much will costs escalate until the project is completed?
- Regional labor factors

In order to develop these different levels of estimating, the following are examples of the type of information to be used:

Initial and Revised PER Estimate

1. Costs from published documents for similar sewer and pumping station construction.
2. Costs for similar construction in the City or nearby communities.
3. Other Estimates of Construction Costs.
4. Bid tabulations with pricing for similar public works projects.
5. Manufacturer's price quotes.
6. Means Catalog Estimating properly interpreted and adjusted for each specific project.
7. Construction Costs based on unit cost databases.
8. Industry accepted percentages for site work, instrumentation and electrical, etc.
9. Contingency allowance on the order of 30% to account for unknown circumstances.

Preliminary (50%) Design Phase Estimate

1. Piping, valve and ancillary costs based on quotes from manufacturers or other sources identified above.
2. Quantity take-offs for concrete and building structure using preliminary wall and slab thickness and dimensions. .
3. Architectural, heating, ventilating, plumbing, fire protection, instrumentation and electrical costs from the design groups.
4. Site work costs.
5. Recommendations from specialty and industry contractors.
6. Contingency allowance on the order of 20% to allow for unknown circumstances.

Final (90% and 100%) Design Phase Estimate

1. Same as above preliminary design except that quantity take-offs, building construction, site work and specialty construction is to be based on a higher level of design development and more reliable costing sources.
2. Contingency allowance on the order of 20%, based on unknowns and other factors.

4.3.6 Contract Document Bid Items

Construction costs for sewer projects should be based on a breakdown of the project elements using the City's standard bid form itemization. These bid items are in lieu of the HRPDC items and are to be the same as reflected in the Proposal form of the Project Manual. A general listing of bid items used by the City is included in Appendix G.

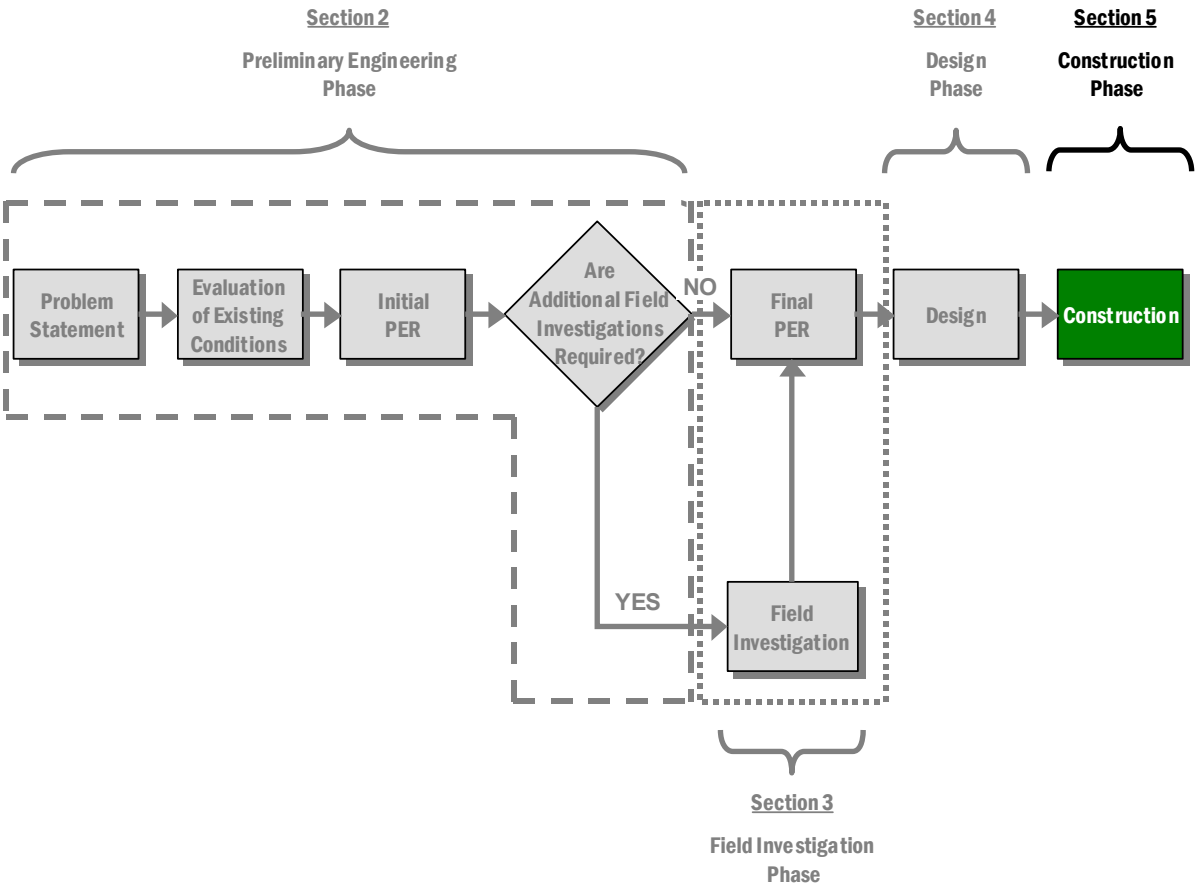
4.3.7 Construction Phase Estimates (Review of Change Order Proposals)

In evaluating change order costs during construction, the Engineer may use the following techniques:

- Compare change order costs to similar costs in the schedule of values submitted by the contractor at the beginning of the construction phase.
- Request and review quotes from suppliers. Whenever feasible obtain quotes from competitive suppliers for comparison. Suppliers' quotes should be on their letterhead to be considered acceptable.
- Review the reasonableness of labor hours and hourly rates. Refer to published sources that establish hourly production rates for such common tasks as welding, sheetrock installation, etc. Check RS Means Labor Rates for the labor rates applicable to various metropolitan areas.

- Review the reasonableness of overhead and profit factors, especially as they compare to the limits specified in the Contract Documents.
- Make sure the general contractor doesn't apply the same overhead and profit rates to subcontracted work as it applies to its work. The general contractor usually marks subcontracted work up about 10 percent, while its own overhead and profit is usually about 20 percent.

Figure 5-1
Construction Phase



SECTION 5
CONSTRUCTION SERVICES

5.1 GENERAL

The Construction Phase is the last phase of the sewershed investigation program, as shown in Figure 5-1. Services during construction are divided into two major categories as follows:

- Office Services
- Field Services

These services may be provided by Utilities' staff, the Engineer or a combination of both, at the option of the City. This section outlines the basic requirements for services during construction.

Figure 5-1
Construction Phase

(Located at the beginning of this section)

5.2 OVERVIEW OF CONSTRUCTION PHASE SERVICES

The types of services provided during construction will depend on the type of project, its duration, and the availability of Utilities' staff to perform certain services (e.g. construction inspection). Utilities will determine the extent of the required services on a project-by-project basis. The following is a summary of the types of construction services that would normally be provided.

1. Office Services During Construction
    a. Review Requests for Information (RFI), review and approve all shop drawings, material and equipment certifications, and other submittals from the Contractor.
    b. Interpret the intent of the Final Plans and Specifications, visit the job site, and advise and consult with Utilities' staff.
    c. Review Contractors Request for Change Orders. During the course of a construction project, work within the general scope of the contract may require modification in some manner. Standard construction contracts give the Owner the right to make changes to the project due to certain requirements and circumstances. Either party to the Contract (Owner or Contractor) can initiate a change order. When the Contractor initiates a change order it is called a Change Order Request (COR). When the Owner initiates a change order it is called and Request for Proposal (RFP). As soon as a change order or claim has been identified perform a cost and time

estimate for each issue. Evaluate this information in the context of the schedule to establish cost and time merit and potential impacts on the budget and project completion.

d. Prepare revised intersection drawings per Utilities' standards in both Mylar (reproducible) and digital formats.

e. Gather, inventory, and provide Operation and Maintenance manual(s), which shall include all manufacturers' equipment literature, warranty information, shop drawings, etc., suitable for use by Utilities and for approval by the Virginia DEQ, as required.

2. Field Services During Construction

a. Provide on-site inspection of construction work in progress, as requested by Utilities.

b. Furnish "As-Built" Mylar (reproducible) tracings to Utilities based on field measurements, specifications, and other pertinent information. A copy of "As-Built" plans is to be provided on a CD computer disk and compatible with Utilities' CAD and GIS systems.

c. Training and Start-up services. As applicable, prepare Certificate of Completion for the Start-up including certificates from vendors that the equipment has been installed properly and that required training has been given.

5.3 OPTIONAL SERVICES

Depending on the nature and timing of the project, Utilities may request that the Engineer provide additional and optional services through the Construction Phase. Such services could include special inspections as required by the City of Norfolk Department of Planning and Community Development or post construction flow monitoring.

Special inspections required of the Engineer may include subgrade, foundation, structural concrete, steel, masonry and others as required by the City. The Engineer should contact the Chief of Construction for Utilities to determine such requirements for special inspections.

Post construction flow monitoring services may be required to demonstrate the effectiveness of a gravity sewer upgrade project in reducing infiltration and inflow. Post construction flow monitoring may also be required to provide comparative data on the effectiveness of various approaches to sewer upgrade and upgrade materials, such as different types of sewer liners.

The information from the post construction flow monitoring will be used to estimate measures of sewer upgrade performance in terms of the following parameters:

- Post construction DWI and RDI/I from the sewershed, expressed as: gallons per day (gpd).

- Post construction per capita unit flows from the sewershed resulting from I/I reduction, expressed as: gallons per capita per day (gpcd).
- The project's I/I removal cost effectiveness expressed as: dollars per gallon of I/I removed. (Cost effectiveness will be estimated for both DWI and RDI/I based on volume in excess of the dry weather ADF and comparison to flow volumes estimated during the Field Investigation phase flow monitoring, as appropriate.)

The results of the post construction flow monitoring will be presented in a report that should follow the requirements of the field inspection flow monitoring discussed in Section 3 of this Manual.

The methodology for performing post construction flow monitoring must be consistent with and in conformance with the methodology presented in Section 3.

5.4 CONSTRUCTION CHECKLISTS

If the Engineer is requested to perform construction inspection, the request may also include providing information on the construction checklists included in the Standard Design Criteria Manual as follows:

- Water and Wastewater Pipelines General Inspection Checklist
- Sewage Pumping Station Construction Inspection Checklist
- Sewer Installation Construction Inspection Checklist
- Pipeline Rehabilitation Construction Inspection Checklist
- Manhole Installation Construction Inspection Checklist
- Pressure Pipe Installation Construction Inspection Checklist
- Large Diameter Pressure Pipe (>16") Inspection Checklist

City of Norfolk, Virginia
Department of Utilities

Sewershed Investigation Guidance Manual

List of Appendices

A. Listing of Previous I/I Reports and Recently Completed LTCP/SS Upgrade Projects
B. Breakdown of Pipe Materials in Norfolk System Sewersheds
C. PER Checklist
D. Procedure and Form for Obtaining Water Consumption Data from City
E. Suggested Sewer Rehabilitation Decision Procedure
F. Field Investigation Forms
    1. Manhole Inspections
    2. Smoke Testing
    3. Pump Station Inspection Checklist
G. City's Measurement Payment Items

City of Norfolk, Virginia
Department of Utilities

Listing of Previous I/I Reports and Recently Completed LTCP/SS Upgrade Projects

Sanitary Sewer System Condition Assessment

Summary of Previous Infiltration/Inflow and SSES Reports

May 2002

A review of previous reports on the City's infiltration and inflow (I/I) investigations and pump station conditions was conducted to gather information on past projects intended to correct I/I in the sanitary sewer system. The findings and recommendations of the reports have been summarized in the SSES document. The reports that were provided by the Department of Utilities include the following and are summarized in this sequence:

A. Sewer Division Evaluation and Rehabilitation Needs Assessment, Summary Report, Presnell Associates, Inc., February 1985.

B. Report of Water and Sanitary Sewer Evaluation Study Willoughby Spit Area, R. Kenneth Weeks Engineers, December 1, 1992

C. Campostella / Campostella Heights Sanitary Sewer Rehabilitation, Final Report, URS Consultants, Inc., December 7, 1992.

D. Sanitary Sewer Evaluation Report, Oak Grove Avenue, Sinclair Street, Newport Avenue, Granby Street and Suburban Parkway, Bengston, DeBell & Elkin, Ltd., December 1992.

E. Sanitary Sewer Rehabilitation Study, Glencove / Lochaven, Lafayette / Winona, and Norview Heights, Final Report, Maguire Associates, Inc., December 1992.

F. Pump Station No. 23 Service Area Sewer Rehabilitation Study, O'Brien & Gere, March 1993.

G. Sanitary Sewer Study for 40th Street, 49th Street, Merrimac Avenue, Bapaume Avenue, Patton Harris Rust & Associates, December 1993.

H. Fox Hall Residency Park / Princess Anne Park Sanitary Sewer Rehabilitation, Final Report, URS Consultants, Inc., May 20, 1994.

I. Brentwood Forest / South Bayview Sewer Rehabilitation Study, O'Brien & Gere, June 1995, Final Report, October 1996.

J. Ghent / West Ghent Sanitary Sewer Rehabilitation, Final Report, URS Greiner, Inc., April 1998.

K. West Ghent Phase 1 Post-Rehab Flow Monitoring Study, URS, September 2000.

L. Pumping Stations 23, 28 and 72 and Associated Force Mains, Clark, Nexsen, Owen, Barbieri, Gibson, November 1994.

M. Study of the Renovation / Replacement of Wastewater Pumping Stations 67, 22 and 16 and Associated Force Mains, C. Allen Bamforth, Jr., 12/12/93.

N. Study of Wastewater Pumping Station 15, C. Allen Bamforth, Jr., September 30, 1994.

O. Operations Study of Pump Stations Nos. 44, 45 and 57, Smith Demer Norman, July 1994.

P. Fairmount Park, Willard Park and Lafayette Terrace Sanitary Sewer and Water Distribution System Upgrade, Phase I Report, March 1998.

City of Norfolk, Virginia
Department of Utilities

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
CI	829	6.0%	7	118.37	---
DI	134	1.0%	16	8.37	---
ESVC	460	3.4%	3	153.41	---
PVC	1,426	10.4%	21	67.92	---
TC	935	6.8%	4	233.81	---
Undetermined[1]	8,607	62.8%	61	141.10	---
VC	1,324	9.7%	9	147.10	---
Total	**13,715**	**100.0%**	**121**	**113.35**	**HRSD-102 Total**
CI	73	0.3%	2	36.40	---
DI	574	2.3%	2	286.80	---
PVC	642	2.6%	4	160.55	---
Undetermined[1]	17,248	69.1%	125	137.98	---
VC	6,431	25.8%	39	164.89	---
Total	**24,967**	**100.0%**	**172**	**145.16**	**HRSD-103 Total**
CI	2,842	2.4%	22	129.19	---
CON	1,101	0.9%	4	275.15	---
DI	552	0.5%	4	137.99	---
ESVC	12,104	10.0%	55	220.07	---
PVC	5,754	4.8%	42	137.01	---
TC	1,156	1.0%	7	165.13	---
TRUS	340	0.3%	1	339.54	---
Undetermined[1]	50,588	41.8%	332	152.37	---
VC	46,455	38.4%	236	196.84	---
Total	**120,891**	**100.0%**	**703**	**171.96**	**HRSD-105 Total**
ABS	820	4.3%	6	136.74	---
CI	844	4.4%	7	120.53	---
DI	74	0.4%	1	73.63	---
PVC	553	2.9%	5	110.66	---
TC	529	2.8%	3	176.35	---
Undetermined[1]	13,767	72.0%	84	163.89	---
VC	2,521	13.2%	12	210.08	---
Total	**19,108**	**100.0%**	**118**	**161.93**	**HRSD-106 Total**
CI	3,864	2.8%	40	96.60	---
DI	743	0.5%	7	106.19	---

[1] Information not currently in the GIS.

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
ESVC	1,085	0.8%	14	77.48	---
PVC	5,961	4.3%	61	97.72	---
TC	2,187	1.6%	6	364.57	---
TRUS	249	0.2%	2	124.30	---
Undetermined[1]	113,558	82.7%	717	158.38	---
VC	9,603	7.0%	64	150.04	---
Total	**137,250**	**100.0%**	**911**	**150.66**	**HRSD-107 Total**
ABS	422	0.4%	2	211.14	---
AC	21	0.0%	1	21.04	---
CI	4,852	4.2%	40	121.31	---
CIMJ	519	0.5%	7	74.14	---
DI	318	0.3%	3	105.84	---
ESVC	2,146	1.9%	12	178.82	---
PVC	1,207	1.1%	14	86.21	---
TC	107	0.1%	1	106.95	---
TRUS	15,108	13.2%	67	225.49	---
Undetermined[1]	27,020	23.6%	259	104.32	---
VC	62,603	54.8%	296	211.50	---
Total	**114,323**	**100.0%**	**702**	**162.85**	**HRSD-108 Total**
CI	2,064	26.4%	18	114.68	---
PVC	364	4.7%	2	181.93	---
TC	616	7.9%	5	123.21	---
Undetermined[1]	4,067	52.0%	34	119.61	---
VC	712	9.1%	4	178.11	---
Total	**7,823**	**100.0%**	**63**	**124.18**	**HRSD-111 Total**
CI	4,456	13.1%	31	143.74	---
DI	133	0.4%	11	12.08	---
ESVC	403	1.2%	2	201.74	---
PVC	4,590	13.5%	30	153.00	---
TC	846	2.5%	5	169.30	---
Undetermined[1]	21,004	61.7%	127	165.39	---
VC	2,590	7.6%	15	172.66	---
Total	**34,023**	**100.0%**	**221**	**153.95**	**HRSD-113 Total**
CI	2,820	7.7%	16	176.26	---
CON	1,167	3.2%	5	233.49	---
DI	50	0.1%	1	50.00	---
DIMJ	279	0.8%	1	278.55	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
PVC	540	1.5%	2	270.07	---
Undetermined[1]	28,603	78.3%	189	151.34	---
VC	3,092	8.5%	17	181.90	---
Total	**36,551**	**100.0%**	**231**	**158.23**	**HRSD-114 Total**
AC	960	2.9%	6	159.94	---
CI	1,705	5.1%	18	94.74	---
DI	296	0.9%	4	74.00	---
DIMJ	122	0.4%	3	40.80	---
ESVC	6,720	20.1%	30	223.99	---
PVC	70	0.2%	3	23.36	---
STL	38	0.1%	1	38.00	---
Undetermined[1]	5,665	16.9%	36	157.37	---
VC	17,920	53.5%	103	173.98	---
Total	**33,496**	**100.0%**	**204**	**164.20**	**HRSD-115 Total**
CI	423	0.5%	5	84.52	---
CON	6,505	7.4%	35	185.84	---
DI	22	0.0%	2	10.78	---
ESVC	1,447	1.7%	8	180.86	---
PEP	79	0.1%	2	39.48	---
PVC	12,946	14.8%	83	155.98	---
TC	1,347	1.5%	5	269.49	---
Undetermined[1]	43,919	50.1%	360	122.00	---
VC	20,998	23.9%	120	174.98	---
Total	**87,685**	**100.0%**	**620**	**141.43**	**HRSD-116 Total**
ABS	93	0.5%	1	93.16	---
CI	1,888	9.3%	9	209.76	---
DI	324	1.6%	3	107.96	---
PVC	1,120	5.5%	7	159.96	---
Undetermined[1]	14,174	69.5%	99	143.18	---
VC	2,800	13.7%	18	155.58	---
Total	**20,399**	**100.0%**	**137**	**148.90**	**HRSD-117 Total**
DI	58	1.0%	1	58.28	---
ESVC	1,726	28.4%	7	246.60	---
PVC	1,095	18.0%	9	121.67	---
TRUS	185	3.0%	1	185.12	---
Undetermined[1]	1,111	18.3%	11	100.98	---
VC	1,906	31.3%	14	136.17	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
Total	**6,082**	**100.0%**	**43**	**141.44**	**HRSD-118 Total**
CI	3,574	4.3%	44	81.23	---
CIMJ	994	1.2%	10	99.45	---
CON	383	0.5%	2	191.45	---
DI	1,903	2.3%	16	118.91	---
ESVC	1,265	1.5%	5	253.08	---
PVC	6,303	7.6%	64	98.48	---
TC	3,889	4.7%	26	149.56	---
TRUS	1,380	1.7%	9	153.38	---
Undetermined[(1)]	59,101	71.6%	528	111.93	---
VC	3,783	4.6%	21	180.12	---
Total	**82,575**	**100.0%**	**725**	**113.90**	**HRSD-121 Total**
CI	850	4.0%	5	169.98	---
CON	1,133	5.4%	5	226.65	---
PVC	815	3.9%	10	81.45	---
Undetermined[(1)]	17,861	84.4%	87	205.30	---
VC	493	2.3%	6	82.14	---
Total	**21,152**	**100.0%**	**113**	**187.18**	**HRSD-122 Total**
ABS	165	1.0%	1	165.45	---
CI	344	2.1%	3	114.75	---
CON	615	3.7%	2	307.61	---
DIMJ	27	0.2%	1	27.12	---
PVC	193	1.2%	5	38.61	---
Undetermined[(1)]	12,620	76.0%	81	155.80	---
VC	2,640	15.9%	14	188.59	---
Total	**16,605**	**100.0%**	**107**	**155.19**	**HRSD-124 Total**
CI	1,313	11.6%	13	101.00	---
DI	70	0.6%	1	70.00	---
ESVC	1,403	12.4%	6	233.88	---
PVC	25	0.2%	1	24.61	---
Undetermined[(1)]	3,363	29.8%	30	112.10	---
VC	5,105	45.3%	27	189.09	---
Total	**11,279**	**100.0%**	**78**	**144.61**	**HRSD-125 Total**
CI	4,677	11.6%	25	187.10	---
CIMJ	796	2.0%	10	79.59	---
PVC	682	1.7%	9	75.77	---
TC	7,013	17.4%	32	219.15	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
Undetermined[1]	21,336	52.8%	140	152.40	---
VC	5,911	14.6%	41	144.17	---
Total	**40,415**	**100.0%**	**257**	**157.26**	**HRSD-126 Total**
C	533	1.3%	2	266.26	---
CI	496	1.3%	7	70.83	---
CIMJ	113	0.3%	1	113.21	---
CON	1,258	3.2%	6	209.73	---
DI	974	2.5%	12	81.18	---
PVC	1,134	2.9%	8	141.78	---
Undetermined[1]	32,798	82.9%	185	177.28	---
VC	2,249	5.7%	13	172.97	---
Total	**39,555**	**100.0%**	**234**	**169.04**	**HRSD-127 Total**
CI	482	1.7%	3	160.55	---
CON	515	1.8%	2	257.70	---
PVC	2,997	10.5%	18	166.50	---
TC	516	1.8%	3	171.92	---
Undetermined[1]	15,107	52.9%	86	175.66	---
VC	8,942	31.3%	34	263.00	---
Total	**28,559**	**100.0%**	**146**	**195.61**	**HRSD-128 Total**
CI	1,410	8.1%	14	100.71	---
CIMJ	171	1.0%	1	171.00	---
DI	220	1.3%	1	220.00	---
PVC	1,365	7.8%	16	85.29	---
TC	96	0.6%	2	48.00	---
Undetermined[1]	6,534	37.6%	50	130.69	---
VC	7,590	43.7%	35	216.85	---
Total	**17,385**	**100.0%**	**119**	**146.10**	**HRSD-130 Total**
CI	919	3.7%	5	183.83	---
TC	2,767	11.2%	12	230.54	---
Undetermined[1]	18,624	75.1%	84	221.72	---
VC	2,487	10.0%	10	248.75	---
Total	**24,797**	**100.0%**	**111**	**223.40**	**HRSD-132 Total**
CI	366	4.8%	4	91.43	---
Undetermined[1]	7,308	95.2%	42	173.99	---
Total	**7,673**	**100.0%**	**46**	**166.81**	**HRSD-141 Total**
CI	574	7.5%	5	114.75	---
PVC	108	1.4%	2	53.97	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
Undetermined[1]	6,788	89.0%	34	199.66	---
VC	160	2.1%	1	160.09	---
Total	**7,630**	**100.0%**	**42**	**181.67**	**HRSD-142 Total**
C	390	1.6%	2	194.86	---
CI	1,911	7.7%	16	119.46	---
CON	732	3.0%	4	183.05	---
TC	4,903	19.9%	20	245.14	---
Undetermined[1]	12,594	51.0%	84	149.93	---
VC	4,164	16.9%	16	260.22	---
Total	**24,694**	**100.0%**	**142**	**173.90**	**HRSD-147 Total**
CI	67	0.6%	2	33.41	---
PVC	507	4.7%	3	168.86	---
TC	776	7.2%	5	155.28	---
Undetermined[1]	5,071	46.9%	40	126.78	---
VC	4,383	40.6%	22	199.21	---
Total	**10,803**	**100.0%**	**72**	**150.05**	**HRSD-148 Total**
ABS	1,240	5.4%	8	154.95	---
CI	2,016	8.8%	17	118.56	---
ESVC	3,349	14.6%	26	128.81	---
PVC	2,325	10.2%	23	101.09	---
TC	559	2.4%	3	186.33	---
TRUS	1,604	7.0%	13	123.35	---
Undetermined[1]	10,530	46.0%	98	107.45	---
VC	1,275	5.6%	14	91.09	---
Total	**22,897**	**100.0%**	**202**	**113.35**	**PS-003 Total**
CI	1,135	2.0%	13	87.34	---
PVC	3,960	7.0%	29	136.56	---
TC	2,455	4.4%	24	102.30	---
Undetermined[1]	47,406	84.1%	337	140.67	---
VC	1,401	2.5%	13	107.77	---
Total	**56,358**	**100.0%**	**416**	**135.48**	**PS-004 Total**
C	273	0.6%	1	272.66	---
CI	349	0.7%	6	58.19	---
ESVC	431	0.9%	2	215.58	---
PEP	755	1.6%	6	125.83	---
PVC	2,963	6.1%	20	148.17	---
TC	1,208	2.5%	6	201.26	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
Undetermined[1]	37,980	78.6%	300	126.60	---
VC	4,371	9.0%	36	121.43	---
Total	**48,330**	**100.0%**	**377**	**128.20**	**PS-005 Total**
CI	202	1.7%	4	50.45	---
PVC	48	0.4%	1	48.30	---
TC	15	0.1%	1	15.05	---
Undetermined[1]	11,008	94.0%	70	157.26	---
VC	437	3.7%	2	218.65	---
Total	**11,711**	**100.0%**	**78**	**150.14**	**PS-006 Total**
CI	1,536	13.2%	11	139.65	---
TC	1,777	15.3%	6	296.25	---
Undetermined[1]	8,051	69.2%	53	151.91	---
VC	270	2.3%	1	270.00	---
Total	**11,635**	**100.0%**	**71**	**163.87**	**PS-007 Total**
CI	4,429	5.6%	36	123.02	---
CIMJ	614	0.8%	2	307.05	---
CON	4,481	5.7%	17	263.60	---
DI	464	0.6%	4	116.08	---
ESVC	151	0.2%	1	150.96	---
PVC	2,969	3.7%	39	76.12	---
TC	8,094	10.2%	37	218.75	---
Undetermined[1]	46,163	58.2%	332	139.05	---
VC	11,944	15.1%	70	170.62	---
Total	**79,309**	**100.0%**	**538**	**147.41**	**PS-008 Total**
CI	1,688	4.9%	17	99.29	---
PVC	407	1.2%	4	101.78	---
TC	1,770	5.1%	10	176.97	---
Undetermined[1]	28,400	82.2%	157	180.89	---
VC	2,266	6.6%	10	226.59	---
Total	**34,530**	**100.0%**	**198**	**174.40**	**PS-009 Total**
ABS	80	0.1%	1	79.95	---
CI	739	0.7%	11	67.20	---
CON	1,960	2.0%	14	140.00	---
DI	76	0.1%	1	76.00	---
PVC	119	0.1%	4	29.76	---
TC	3,562	3.6%	9	395.77	---
Undetermined[1]	90,562	90.3%	435	208.19	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
VC	3,165	3.2%	18	175.85	---
Total	**100,263**	**100.0%**	**493**	**203.37**	**PS-010 Total**
CI	867	1.4%	5	173.45	---
CON	1,023	1.6%	3	341.07	---
DI	3,760	5.9%	41	91.71	---
DIMJ	27	0.0%	1	27.00	---
PVC	115	0.2%	3	38.33	---
STL	10	0.0%	1	9.64	---
Undetermined[(1)]	55,142	85.9%	278	198.35	---
VC	3,234	5.0%	16	202.12	---
Total	**64,179**	**100.0%**	**348**	**184.42**	**PS-011 Total**
CI	287	1.5%	4	71.87	---
CON	250	1.3%	1	250.00	---
DI	320	1.7%	2	160.00	---
PVC	87	0.4%	1	86.59	---
TC	231	1.2%	2	115.32	---
Undetermined[(1)]	18,167	93.9%	98	185.38	---
Total	**19,342**	**100.0%**	**108**	**179.09**	**PS-012 Total**
CI	1,548	3.9%	11	140.71	---
CON	996	2.5%	6	166.00	---
DI	208	0.5%	1	207.82	---
PVC	266	0.7%	4	66.43	---
Undetermined[(1)]	30,061	75.6%	203	148.08	---
VC	6,689	16.8%	34	196.74	---
Total	**39,768**	**100.0%**	**259**	**153.54**	**PS-013 Total**
ABS	381	0.6%	2	190.36	---
AC	825	1.2%	6	137.57	---
CI	4,585	6.8%	37	123.93	---
CIMJ	1,336	2.0%	9	148.44	---
CON	3,761	5.5%	15	250.72	---
DI	641	0.9%	5	128.23	---
PVC	2,138	3.2%	13	164.50	---
TC	1,919	2.8%	8	239.90	---
Undetermined[(1)]	41,281	60.9%	246	167.81	---
VC	10,914	16.1%	60	181.91	---
Total	**67,783**	**100.0%**	**401**	**169.03**	**PS-015 Total**
ABS	165	1.3%	8	20.60	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
AC	569	4.5%	3	189.74	---
C	239	1.9%	1	238.86	---
CI	98	0.8%	5	19.54	---
CIMJ	144	1.1%	5	28.84	---
CON	277	2.2%	1	276.70	---
Undetermined[(1)]	10,934	86.1%	85	128.64	---
VC	280	2.2%	5	56.04	---
Total	**12,706**	**100.0%**	**113**	**112.44**	**PS-016 Total**
C	1,664	3.2%	7	237.77	---
CI	2,106	4.1%	21	100.26	---
CON	1,247	2.4%	5	249.31	---
DI	488	0.9%	7	69.66	---
ESVC	2,228	4.3%	9	247.56	---
PVC	1,458	2.8%	8	182.29	---
TC	1,809	3.5%	10	180.95	---
Undetermined[(1)]	27,233	52.6%	196	138.94	---
VC	13,556	26.2%	76	178.36	---
Total	**51,788**	**100.0%**	**339**	**152.77**	**PS-017 Total**
ABS	1,396	1.3%	6	232.74	---
C	254	0.2%	1	253.52	---
CI	3,253	3.0%	27	120.50	---
CON	13,627	12.5%	55	247.76	---
DI	1,045	1.0%	13	80.40	---
ESVC	663	0.6%	3	221.15	---
PVC	4,230	3.9%	40	105.74	---
TC	12,773	11.7%	61	209.39	---
Undetermined[(1)]	48,154	44.2%	389	123.79	---
VC	23,622	21.7%	130	181.71	---
Total	**109,017**	**100.0%**	**725**	**150.37**	**PS-018 Total**
C	464	2.1%	2	231.95	---
CI	110	0.5%	5	21.91	---
CON	569	2.6%	2	284.58	---
DI	483	2.2%	9	53.70	---
PVC	1,400	6.4%	6	233.28	---
Undetermined[(1)]	10,661	48.5%	63	169.21	---
VC	8,300	37.8%	34	244.12	---
Total	**21,986**	**100.0%**	**121**	**181.71**	**PS-019 Total**

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
AC	806	5.4%	6	134.32	---
CI	536	3.6%	13	41.27	---
Undetermined[1]	12,802	85.3%	63	203.20	---
VC	865	5.8%	4	216.25	---
Total	**15,009**	**100.0%**	**86**	**174.53**	**PS-020 Total**
C	221	0.4%	1	220.84	---
CI	1,557	3.1%	7	222.44	---
CON	3,844	7.5%	22	174.75	---
DI	1,017	2.0%	17	59.83	---
PVC	823	1.6%	11	74.84	---
TC	803	1.6%	3	267.77	---
Undetermined[1]	37,096	72.8%	234	158.53	---
VC	5,572	10.9%	37	150.59	---
Total	**50,934**	**100.0%**	**332**	**153.41**	**PS-021 Total**
C	857	7.8%	4	214.37	---
CI	675	6.1%	14	48.19	---
CON	1,091	9.9%	5	218.26	---
DI	85	0.8%	1	85.41	---
ESVC	197	1.8%	1	196.72	---
PVC	1,177	10.7%	13	90.51	---
Undetermined[1]	6,961	63.0%	74	94.07	---
Total	**11,044**	**100.0%**	**112**	**98.60**	**PS-022 Total**
AC	76	0.1%	2	38.01	---
C	57	0.1%	1	57.20	---
CI	3,851	3.4%	31	124.22	---
CON	251	0.2%	1	250.72	---
DI	577	0.5%	5	115.48	---
ESVC	5,440	4.9%	25	217.58	---
PVC	9,219	8.3%	55	167.62	---
TC	7,205	6.4%	33	218.32	---
Undetermined[1]	36,132	32.3%	272	132.84	---
VC	48,909	43.8%	240	203.79	---
Total	**111,716**	**100.0%**	**665**	**167.99**	**PS-023 Total**
Undetermined[1]	2,321	100.0%	19	122.18	---
Total	**2,321**	**100.0%**	**19**	**122.18**	**PS-025 Total**
CI	459	3.7%	4	114.66	---
Undetermined[1]	11,741	95.4%	82	143.18	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
VC	108	0.9%	1	108.09	---
Total	**12,307**	**100.0%**	**87**	**141.46**	**PS-026 Total**
ABS	265	0.3%	2	132.55	---
C	126	0.1%	1	125.79	---
CI	2,194	2.5%	18	121.87	---
CON	3,243	3.7%	19	170.67	---
DI	164	0.2%	2	82.05	---
PVC	1,831	2.1%	16	114.43	---
TC	1,413	1.6%	13	108.70	---
Undetermined[(1)]	60,545	68.6%	377	160.60	---
VC	18,514	21.0%	103	179.74	---
Total	**88,294**	**100.0%**	**551**	**160.24**	**PS-027 Total**
C	307	1.2%	2	153.62	---
CI	399	1.6%	3	133.16	---
CON	2,349	9.3%	11	213.57	---
PVC	254	1.0%	2	127.08	---
Undetermined[(1)]	12,788	50.6%	82	155.95	---
VC	9,164	36.3%	50	183.29	---
Total	**25,262**	**100.0%**	**150**	**168.41**	**PS-028 Total**
Undetermined[(1)]	1,415	30.6%	12	117.92	---
VC	3,209	69.4%	15	213.92	---
Total	**4,624**	**100.0%**	**27**	**171.25**	**PS-029 Total**
CI	559	1.6%	7	79.89	---
DI	265	0.7%	7	37.80	---
ESVC	5,460	15.1%	30	182.02	---
PVC	8,920	24.7%	59	151.18	---
Undetermined[(1)]	3,975	11.0%	62	64.12	---
VC	16,887	46.8%	80	211.08	---
Total	**36,066**	**100.0%**	**245**	**147.21**	**PS-030 Total**
DI	76	1.6%	1	76.37	---
Undetermined[(1)]	547	11.6%	8	68.44	---
VC	4,102	86.8%	39	105.17	---
Total	**4,725**	**100.0%**	**48**	**98.45**	**PS-031 Total**
ABS	312	0.3%	2	155.87	---
CI	9,377	9.3%	48	195.36	---
CIMJ	84	0.1%	1	83.55	---
DI	387	0.4%	2	193.30	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
ESVC	2,512	2.5%	10	251.16	---
PVC	2,229	2.2%	28	79.62	---
TC	30	0.0%	1	29.65	---
Undetermined[1]	21,460	21.2%	211	101.70	---
VC	64,853	64.1%	387	167.58	---
Total	**101,242**	**100.0%**	**690**	**146.73**	**PS-032 Total**
C	224	0.3%	1	224.13	---
CI	433	0.6%	6	72.17	---
CIMJ	272	0.4%	1	271.77	---
DI	50	0.1%	1	49.72	---
ESVC	11,549	17.3%	48	240.60	---
PVC	998	1.5%	11	90.74	---
TC	111	0.2%	3	37.04	---
Undetermined[1]	7,433	11.1%	105	70.79	---
VC	45,754	68.5%	219	208.92	---
Total	**66,824**	**100.0%**	**395**	**169.17**	**PS-033 Total**
C	1,199	4.6%	8	149.89	---
CI	1,518	5.9%	26	58.37	---
CIMJ	109	0.4%	4	27.32	---
CON	187	0.7%	1	187.18	---
DI	2,574	10.0%	13	198.02	---
PVC	465	1.8%	14	33.20	---
Undetermined[1]	15,747	60.9%	119	132.33	---
VC	4,054	15.7%	23	176.27	---
Total	**25,854**	**100.0%**	**208**	**124.30**	**PS-034 Total**
CI	1,104	5.7%	5	220.78	---
CIMJ	46	0.2%	4	11.48	---
DI	313	1.6%	1	312.93	---
TC	325	1.7%	1	325.08	---
Undetermined[1]	14,976	76.8%	167	89.67	---
VC	2,729	14.0%	17	160.56	---
Total	**19,493**	**100.0%**	**195**	**99.96**	**PS-035 Total**
CI	785	6.1%	12	65.43	---
CIMJ	22	0.2%	1	21.95	---
PVC	510	4.0%	4	127.40	---
Undetermined[1]	10,285	80.0%	57	180.44	---
VC	1,251	9.7%	5	250.15	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
Total	**12,853**	**100.0%**	**79**	**162.69**	**PS-036 Total**
CI	198	4.5%	7	28.24	---
PVC	41	0.9%	3	13.78	---
Undetermined[(1)]	3,404	76.8%	21	162.09	---
VC	787	17.8%	5	157.31	---
Total	**4,430**	**100.0%**	**36**	**123.04**	**PS-037 Total**
ABS	38	0.1%	1	38.46	---
AC	382	1.1%	5	76.34	---
CIMJ	182	0.5%	1	182.00	---
PVC	1,317	3.6%	10	131.71	---
Undetermined[(1)]	30,880	85.3%	153	201.83	---
VC	3,382	9.3%	15	225.46	---
Total	**36,181**	**100.0%**	**185**	**195.57**	**PS-038 Total**
DI	611	7.5%	3	203.68	---
PVC	7,424	90.9%	40	185.59	---
Undetermined[(1)]	132	1.6%	12	11.01	---
Total	**8,167**	**100.0%**	**55**	**148.49**	**PS-039 Total**
PVC	1,351	96.0%	12	112.62	---
Undetermined[(1)]	56	4.0%	9	6.26	---
Total	**1,408**	**100.0%**	**21**	**67.04**	**PS-041 Total**
ABS	5,932	70.9%	42	141.24	---
DI	288	3.4%	3	95.98	---
PVC	156	1.9%	4	38.93	---
Undetermined[(1)]	1,985	23.7%	13	152.72	---
Total	**8,361**	**100.0%**	**62**	**134.86**	**PS-042 Total**
ABS	2,677	36.8%	12	223.07	---
DI	41	0.6%	2	20.58	---
PVC	4,502	61.9%	20	225.10	---
Undetermined[(1)]	49	0.7%	8	6.12	---
Total	**7,269**	**100.0%**	**42**	**173.07**	**PS-043 Total**
CI	1,234	3.0%	9	137.09	---
CON	359	0.9%	1	359.05	---
DI	55	0.1%	1	54.95	---
ESVC	300	0.7%	1	300.10	---
PVC	403	1.0%	4	100.70	---
TC	759	1.8%	5	151.72	---
Undetermined[(1)]	31,571	76.4%	160	197.32	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
VC	6,651	16.1%	35	190.03	---
Total	**41,331**	**100.0%**	**216**	**191.35**	**PS-044 Total**
CI	27	0.2%	2	13.31	---
DI	49	0.3%	1	49.34	---
PVC	2,198	13.2%	27	81.39	---
Undetermined[(1)]	10,379	62.5%	71	146.18	---
VC	3,942	23.8%	21	187.72	---
Total	**16,594**	**100.0%**	**122**	**136.02**	**PS-045 Total**
CI	4,050	5.8%	32	126.56	---
DI	2,306	3.3%	31	74.38	---
ESVC	510	0.7%	2	255.17	---
PVC	1,099	1.6%	17	64.62	---
TC	33	0.0%	1	32.80	---
Undetermined[(1)]	46,722	66.6%	470	99.41	---
VC	15,455	22.0%	112	137.99	---
Total	**70,175**	**100.0%**	**665**	**105.53**	**PS-046 Total**
DI	197	0.9%	5	39.50	---
PVC	82	0.4%	3	27.34	---
Undetermined[(1)]	5,198	24.7%	51	101.92	---
VC	15,577	74.0%	68	229.07	---
Total	**21,055**	**100.0%**	**127**	**165.78**	**PS-047 Total**
PVC	188	1.2%	4	46.96	---
Undetermined[(1)]	15,365	97.9%	84	182.91	---
VC	139	0.9%	1	139.35	---
Total	**15,692**	**100.0%**	**89**	**176.31**	**PS-048 Total**
PVC	2,878	76.5%	12	239.87	---
Undetermined[(1)]	476	12.7%	15	31.74	---
VC	406	10.8%	4	101.55	---
Total	**3,761**	**100.0%**	**31**	**121.31**	**PS-049 Total**
ABS	80	0.4%	1	80.50	---
CI	748	3.4%	11	67.97	---
CON	536	2.4%	3	178.82	---
DI	576	2.6%	5	115.21	---
ESVC	350	1.6%	1	349.93	---
PVC	758	3.5%	6	126.39	---
TC	403	1.8%	3	134.27	---
Undetermined[(1)]	13,811	63.0%	107	129.08	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
VC	4,657	21.2%	26	179.13	---
Total	**21,920**	**100.0%**	**163**	**134.48**	**PS-051 Total**
CON	168	1.3%	2	83.77	---
PVC	342	2.7%	9	37.95	---
TC	120	0.9%	2	60.13	---
Undetermined[(1)]	8,124	63.7%	65	124.98	---
VC	4,006	31.4%	22	182.11	---
Total	**12,759**	**100.0%**	**100**	**127.59**	**PS-052 Total**
CI	578	100.0%	5	115.60	---
Total	**578**	**100.0%**	**5**	**115.60**	**PS-056 Total**
CI	5,766	3.9%	50	115.32	---
CIMJ	49	0.0%	1	49.33	---
DI	214	0.1%	1	213.81	---
ESVC	12,293	8.4%	58	211.95	---
PVC	5,874	4.0%	74	79.38	---
STL	58	0.0%	1	58.19	---
TC	267	0.2%	5	53.45	---
TRUS	159	0.1%	1	158.58	---
Undetermined[(1)]	34,158	23.2%	335	101.96	---
VC	88,323	60.0%	434	203.51	---
Total	**147,162**	**100.0%**	**960**	**153.29**	**PS-057 Total**
CI	147	0.6%	1	146.60	---
Undetermined[(1)]	22,782	98.4%	223	102.16	---
VC	229	1.0%	1	229.12	---
Total	**23,158**	**100.0%**	**225**	**102.92**	**PS-058 Total**
CI	666	2.1%	6	111.07	---
CIMJ	84	0.3%	5	16.77	---
DI	14	0.0%	1	14.02	---
ESVC	3,886	12.0%	20	194.28	---
PVC	1,029	3.2%	9	114.35	---
TC	159	0.5%	4	39.63	---
Undetermined[(1)]	5,573	17.2%	61	91.36	---
VC	20,933	64.7%	107	195.64	---
Total	**32,344**	**100.0%**	**213**	**151.85**	**PS-059 Total**
C	216	2.2%	1	215.71	---
CI	530	5.4%	7	75.74	---
DI	44	0.5%	2	22.05	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
PVC	104	1.1%	1	104.01	---
Undetermined[1]	8,522	87.0%	64	133.15	---
VC	381	3.9%	2	190.58	---
Total		**100.0%**	**77**	**127.23**	**PS-060 Total**
CI	2,755	32.3%	15	183.69	---
PVC	65	0.8%	1	64.98	---
Undetermined[1]	5,257	61.7%	39	134.81	---
VC	442	5.2%	2	221.08	---
Total	**8,520**	**100.0%**	**57**	**149.47**	**PS-061 Total**
ABS	679	2.5%	7	96.97	---
CI	221	0.8%	8	27.62	---
CIMJ	25	0.1%	2	12.58	---
PVC	872	3.2%	4	218.02	---
TC	669	2.4%	6	111.48	---
Undetermined[1]	23,460	85.6%	143	164.06	---
VC	1,470	5.4%	7	209.94	---
Total	**27,396**	**100.0%**	**177**	**154.78**	**PS-063 Total**
CI	133	1.6%	3	44.50	---
PVC	1,343	16.1%	12	111.91	---
Undetermined[1]	1,548	18.5%	12	129.01	---
VC	5,322	63.8%	27	197.09	---
Total	**8,346**	**100.0%**	**54**	**154.56**	**PS-064 Total**
AC	100	1.9%	1	100.30	---
CI	58	1.1%	5	11.66	---
ESVC	1,500	28.0%	6	249.96	---
PVC	1,573	29.4%	15	104.86	---
Undetermined[1]	35	0.7%	7	5.01	---
VC	2,081	38.9%	16	130.09	---
Total	**5,348**	**100.0%**	**50**	**106.95**	**PS-065 Total**
CI	3,051	9.4%	30	101.70	---
CIMJ	148	0.5%	2	74.18	---
DI	267	0.8%	2	133.47	---
ESVC	1,427	4.4%	7	203.84	---
PVC	1,973	6.1%	14	140.89	---
TC	355	1.1%	2	177.28	---
Undetermined[1]	6,465	19.9%	90	71.83	---
VC	18,846	57.9%	100	188.46	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
Total	**32,531**	**100.0%**	**247**	**131.71**	**PS-066 Total**
CI	680	3.1%	5	136.08	---
CIMJ	269	1.2%	1	269.43	---
CON	5,648	26.1%	34	166.12	---
DI	466	2.2%	6	77.71	---
ESVC	2,375	11.0%	10	237.54	---
PVC	980	4.5%	4	245.11	---
TC	64	0.3%	1	64.02	---
Undetermined[(1)]	8,216	38.0%	102	80.55	---
VC	2,926	13.5%	26	112.55	---
Total		**100.0%**	**189**	**114.42**	**PS-067 Total**
CI	3,134	6.4%	22	142.44	---
CIMJ	566	1.2%	7	80.83	---
Undetermined[(1)]	10,590	21.7%	71	149.16	---
VC	34,457	70.7%	159	216.71	---
Total	**48,747**	**100.0%**	**259**	**188.21**	**PS-068 Total**
ABS	95	0.3%	3	31.77	---
CI	891	3.0%	14	63.65	---
CIMJ	243	0.8%	5	48.61	---
ESVC	3,219	10.7%	15	214.60	---
PVC	3,922	13.0%	20	196.10	---
Undetermined[(1)]	6,788	22.5%	82	82.78	---
VC	14,970	49.7%	82	182.56	---
Total	**30,129**	**100.0%**	**221**	**136.33**	**PS-069 Total**
CI	512	1.8%	4	128.11	---
DI	24	0.1%	10	2.39	---
ESVC	561	2.0%	3	186.85	---
PVC	880	3.1%	13	67.70	---
Undetermined[(1)]	4,965	17.6%	48	103.45	---
VC	21,283	75.4%	96	221.70	---
Total	**28,226**	**100.0%**	**174**	**162.22**	**PS-070 Total**
CI	276	1.0%	2	137.88	---
CIMJ	316	1.1%	3	105.19	---
PEP	255	0.9%	1	254.98	---
PVC	296	1.1%	3	98.51	---
TC	343	1.2%	1	342.81	---
Undetermined[(1)]	22,875	81.5%	120	190.63	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Reach (ft)	Pumping Station ID
VC	3,694	13.2%	20	184.72	---
Total	**28,054**	**100.0%**	**150**	**187.03**	**PS-071 Total**
CI	2,172	8.9%	10	217.22	---
DI	10	0.0%	1	10.00	---
ESVC	152	0.6%	1	151.65	---
PVC	697	2.9%	8	87.08	---
TRUS	265	1.1%	1	264.85	---
Undetermined[(1)]	5,721	23.5%	79	72.42	---
VC	15,325	63.0%	81	189.20	---
Total	**24,342**	**100.0%**	**181**	**134.49**	**PS-072 Total**
CI	1,192	28.7%	12	99.33	---
DI	179	4.3%	3	59.82	---
PVC	410	9.9%	2	204.97	---
Undetermined[(1)]	1,656	39.9%	15	110.38	---
VC	717	17.3%	6	119.45	---
Total	**4,154**	**100.0%**	**38**	**109.31**	**PS-073 Total**
CI	185	18.1%	14	13.20	---
CIMJ	10	1.0%	2	5.00	---
Undetermined[(1)]	825	80.9%	7	117.92	---
	1,020	**100.0%**	**23**	**44.36**	**PS-074 Total**
ABS	910	1.5%	5	182.06	---
CI	421	0.7%	5	84.21	---
CIMJ	87	0.1%	1	86.83	---
DI	460	0.7%	4	114.88	---
ESVC	5,717	9.2%	25	228.68	---
PVC	1,880	3.0%	6	313.26	---
Undetermined[(1)]	19,731	31.6%	138	142.98	---
VC	33,177	53.2%	186	178.37	---
	62,382	**100.0%**	**370**	**168.60**	**PS-076 Total**
C	128	0.2%	1	128.27	---
CI	806	1.3%	6	134.27	---
CIMJ	430	0.7%	13	33.04	---
DI	83	0.1%	1	82.62	---
ESVC	7,930	12.7%	37	214.33	---
PVC	3,539	5.6%	17	208.16	---
Undetermined[(1)]	8,083	12.9%	126	64.15	---
VC	41,665	66.5%	230	181.15	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
	62,663	**100.0%**	**431**	**145.39**	**PS-077 Total**
ABS	179	6.7%	1	178.68	---
CI	77	2.9%	1	76.50	---
Undetermined[(1)]	773	29.2%	8	96.61	---
VC	1,622	61.2%	4	405.54	---
Total	**2,650**	**100.0%**	**14**	**189.30**	**PS-079 Total**
CI	1,891	28.6%	9	210.09	---
CIMJ	507	7.7%	4	126.81	---
DI	440	6.6%	2	219.91	---
STL	325	4.9%	2	162.52	---
Undetermined[(1)]	3,256	49.2%	36	90.45	---
VC	204	3.1%	5	40.72	---
Total	**6,623**	**100.0%**	**58**	**114.19**	**PS-080 Total**
AC	804	1.7%	6	133.98	---
CI	1,900	4.0%	22	86.37	---
CIMJ	52	0.1%	1	51.92	---
DIMJ	72	0.2%	1	72.00	---
ESVC	284	0.6%	1	283.66	---
PVC	1,021	2.2%	8	127.63	---
Undetermined[(1)]	4,972	10.5%	105	47.36	---
VC	38,310	80.8%	179	214.02	---
Total	**47,415**	**100.0%**	**323**	**146.80**	**PS-081 Total**
CI	878	8.0%	11	79.79	---
CIMJ	441	4.0%	10	44.14	---
TC	92	0.8%	1	92.00	---
Undetermined[(1)]	304	2.8%	9	33.81	---
VC	9,192	84.3%	57	161.26	---
Total	**10,907**	**100.0%**	**88**	**123.94**	**PS-082 Total**
ABS	586	1.0%	2	292.90	---
CI	2,454	4.1%	19	129.17	---
CIMJ	444	0.7%	10	44.37	---
DI	668	1.1%	21	31.81	---
ESVC	3,898	6.5%	22	177.17	---
PVC	3,647	6.1%	26	140.26	---
TC	35	0.1%	2	17.63	---
Undetermined[(1)]	10,186	16.9%	105	97.01	---
VC	38,286	63.6%	242	158.21	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
	60,203	**100.0%**	**449**	**134.08**	**PS-083 Total**
CI	335	0.7%	5	67.02	---
PVC	1,395	2.8%	6	232.51	---
Undetermined[(1)]	5,558	11.0%	55	101.06	---
VC	43,186	85.6%	204	211.70	---
Total	**50,475**	**100.0%**	**270**	**186.94**	**PS-084 Total**
AC	210	0.6%	2	105.15	---
CI	1,813	5.2%	18	100.73	---
CIMJ	477	1.4%	4	119.31	---
DI	339	1.0%	7	48.42	---
ESVC	510	1.5%	2	255.13	---
PVC	1,977	5.7%	20	98.85	---
Undetermined[(1)]	7,334	21.1%	89	82.40	---
VC	22,057	63.5%	126	175.06	---
Total	**34,718**	**100.0%**	**268**	**129.54**	**PS-085 Total**
CI	1,885	15.2%	16	117.80	---
CIMJ	50	0.4%	1	49.75	---
PVC	704	5.7%	8	87.94	---
TC	35	0.3%	1	35.20	---
Undetermined[(1)]	4,507	36.2%	38	118.61	---
VC	5,254	42.3%	28	187.64	---
Total	**12,434**	**100.0%**	**92**	**135.16**	**PS-086 Total**
C	114	0.3%	1	113.96	---
CI	517	1.4%	5	103.37	---
CIMJ	127	0.4%	1	127.27	---
ESVC	53	0.1%	1	52.61	---
PVC	176	0.5%	1	176.19	---
Undetermined[(1)]	23,752	66.1%	261	91.01	---
VC	11,180	31.1%	61	183.28	---
Total	**35,919**	**100.0%**	**331**	**108.52**	**PS-087 Total**
C	293	0.6%	1	293.00	---
CI	3,220	6.7%	26	123.84	---
CIMJ	146	0.3%	1	146.28	---
DI	427	0.9%	6	71.22	---
ESVC	2,204	4.6%	10	220.36	---
PVC	1,679	3.5%	20	83.93	---
STL	673	1.4%	4	168.16	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
Undetermined[1]	6,247	12.9%	74	84.42	---
VC	33,508	69.2%	157	213.43	---
Total	**48,396**	**100.0%**	**299**	**161.86**	**PS-088 Total**
CI	1,853	6.5%	19	97.54	---
CIMJ	9	0.0%	1	8.57	---
DI	246	0.9%	2	123.01	---
ESVC	170	0.6%	1	170.00	---
PVC	11	0.0%	1	11.25	---
Undetermined[1]	4,604	16.2%	51	90.26	---
VC	21,475	75.7%	121	177.48	---
Total	**28,367**	**100.0%**	**196**	**144.73**	**PS-089 Total**
CI	1,259	3.3%	7	179.88	---
CIMJ	84	0.2%	6	13.92	---
ESVC	1,768	4.7%	6	294.60	---
TC	149	0.4%	1	148.72	---
Undetermined[1]	2,524	6.7%	31	81.42	---
VC	31,812	84.6%	175	181.78	---
Total	**37,595**	**100.0%**	**226**	**166.35**	**PS-090 Total**
ABS	1,216	3.0%	6	202.70	---
CI	3,536	8.8%	39	90.68	---
DI	94	0.2%	3	31.49	---
ESVC	1,704	4.3%	8	212.94	---
PVC	1,647	4.1%	12	137.24	---
TC	37	0.1%	1	36.71	---
Undetermined[1]	6,923	17.3%	80	86.54	---
VC	24,885	62.1%	118	210.89	---
Total	**40,043**	**100.0%**	**267**	**149.97**	**PS-091 Total**
CI	49	0.2%	1	48.62	---
CIMJ	833	3.8%	4	208.27	---
DI	1,182	5.4%	9	131.29	---
ESVC	795	3.7%	4	198.73	---
PVC	271	1.2%	6	45.10	---
Undetermined[1]	7,089	32.7%	51	139.00	---
VC	11,482	52.9%	59	194.62	---
Total	**21,700**	**100.0%**	**134**	**161.94**	**PS-092 Total**
CI	531	1.1%	2	265.50	---
CIMJ	559	1.2%	3	186.34	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
ESVC	10,410	22.1%	44	236.59	---
Undetermined[1]	8,486	18.0%	74	114.67	---
VC	27,048	57.5%	121	223.54	---
Total	**47,034**	**100.0%**	**244**	**192.76**	**PS-093 Total**
CI	62	0.9%	1	61.99	---
CIMJ	209	3.0%	1	208.81	---
ESVC	1,507	21.8%	8	188.43	---
TC	9	0.1%	1	8.68	---
Undetermined[1]	3,613	52.2%	31	116.53	---
VC	1,519	22.0%	9	168.79	---
Total	**6,919**	**100.0%**	**51**	**135.66**	**PS-094 Total**
CIMJ	483	15.4%	6	80.43	---
DI	449	14.4%	4	112.27	---
ESVC	1,547	49.5%	8	193.40	---
Undetermined[1]	444	14.2%	8	55.46	---
VC	204	6.5%	3	68.15	---
Total	**3,127**	**100.0%**	**29**	**107.83**	**PS-095 Total**
AC	280	1.1%	7	40.07	---
DI	32	0.1%	1	31.51	---
PVC	2,212	8.7%	12	184.31	---
Undetermined[1]	435	1.7%	18	24.16	---
VC	22,502	88.4%	110	204.56	---
Total	**25,460**	**100.0%**	**148**	**172.03**	**PS-096 Total**
CI	772	2.2%	7	110.26	---
CIMJ	380	1.1%	2	190.19	---
ESVC	263	0.8%	1	263.00	---
PVC	106	0.3%	2	52.98	---
Undetermined[1]	28,668	82.9%	236	121.48	---
VC	4,381	12.7%	28	156.45	---
Total	**34,570**	**100.0%**	**276**	**125.25**	**PS-097 Total**
CI	237	2.3%	2	118.30	---
DI	2,295	22.3%	32	71.72	---
PVC	694	6.7%	8	86.81	---
Undetermined[1]	5,844	56.8%	73	80.06	---
VC	1,220	11.9%	7	174.28	---
Total	**10,290**	**100.0%**	**122**	**84.34**	**PS-098 Total**
CI	142	1.3%	3	47.49	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
DI	137	1.2%	2	68.44	---
PVC	401	3.7%	3	133.69	---
Undetermined[1]	6,275	57.2%	51	123.03	---
VC	4,015	36.6%	22	182.49	---
Total		**100.0%**	**81**	**135.43**	**PS-100 Total**
CI	11	0.1%	1	11.28	---
DI	55	0.3%	1	54.84	---
ESVC	261	1.2%	1	260.91	---
PVC	127	0.6%	4	31.77	---
Undetermined[1]	1,183	5.5%	45	26.30	---
VC	19,799	92.4%	91	217.57	---
Total		**100.0%**	**143**	**149.90**	**PS-101 Total**
ABS	461	2.8%	3	153.71	---
CI	466	2.9%	5	93.10	---
DI	100	0.6%	2	49.97	---
Undetermined[1]	12,810	78.5%	74	173.11	---
VC	2,478	15.2%	12	206.53	---
Total		**100.0%**	**96**	**169.95**	**PS-102 Total**
C	312	1.6%	1	311.72	---
CI	688	3.6%	9	76.49	---
CON	403	2.1%	2	201.50	---
DI	753	4.0%	5	150.65	---
PVC	410	2.2%	4	102.42	---
Undetermined[1]	14,556	76.4%	84	173.29	---
VC	1,919	10.1%	11	174.44	---
Total		**100.0%**	**116**	**164.15**	**PS-103 Total**
CI	249	2.4%	3	82.96	---
DI	288	2.8%	8	36.03	---
PVC	580	5.6%	4	145.00	---
Undetermined[1]	8,756	83.9%	46	190.35	---
VC	568	5.4%	5	113.62	---
Total		**100.0%**	**66**	**158.20**	**PS-104 Total**
CI	99	0.6%	2	49.33	---
Undetermined[1]	12,944	76.9%	83	155.95	---
VC	3,792	22.5%	16	236.98	---
Total	**16,834**	**100.0%**	**101**	**166.68**	**PS-105 Total**
CI	9	0.5%	5	1.88	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
PVC	1,755	97.5%	17	103.21	---
Undetermined[1]	35	2.0%	5	7.03	---
Total	**1,799**	**100.0%**	**27**	**66.63**	**PS-106 Total**
PVC	2,120	98.0%	19	111.56	---
Undetermined[1]	32	1.5%	4	8.00	---
VC	10	0.5%	1	10.22	---
Total	**2,162**	**100.0%**	**24**	**90.07**	**PS-107 Total**
DI	355	5.9%	5	71.01	---
PVC	4,224	70.6%	21	201.12	---
Undetermined[1]	696	11.6%	18	38.67	---
VC	709	11.8%	6	118.13	---
Total	**5,983**	**100.0%**	**50**	**119.67**	**PS-108 Total**
ABS	35	0.4%	1	35.24	---
C	256	2.8%	2	127.81	---
CI	691	7.5%	3	230.43	---
CON	1,728	18.7%	7	246.80	---
DI	39	0.4%	1	39.08	---
PVC	1,079	11.7%	8	134.84	---
Undetermined[1]	4,481	48.5%	43	104.20	---
VC	936	10.1%	6	156.00	---
Total	**9,244**	**100.0%**	**71**	**130.20**	**PS-109 Total**
CIMJ	405	19.8%	7	57.89	---
DI	128	6.3%	8	16.04	---
PVC	325	15.9%	5	65.02	---
Undetermined[1]	1,190	58.1%	20	59.50	---
Total	**2,049**	**100.0%**	**40**	**51.22**	**PS-110 Total**
DI	5	0.1%	1	5.27	---
PVC	1,342	16.4%	18	74.57	---
Undetermined[1]	6,829	83.3%	34	200.85	---
VC	21	0.3%	1	21.25	---
Total	**8,198**	**100.0%**	**54**	**151.81**	**PS-111 Total**
CI	561	16.7%	2	280.45	---
DI	18	0.5%	1	17.57	---
PVC	583	17.3%	3	194.28	---
Undetermined[1]	2,133	63.5%	24	88.86	---
VC	65	1.9%	1	65.32	---
Total	**3,359**	**100.0%**	**31**	**108.37**	**PS-112 Total**

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
CI	473	5.4%	2	236.42	---
DI	18	0.2%	1	18.48	---
PVC	693	7.9%	10	69.29	---
Undetermined[(1)]	6,542	74.1%	50	130.85	---
VC	1,099	12.5%	4	274.84	---
	8,826	**100.0%**	**67**	**131.73**	**PS-113 Total**
CI	148	5.8%	2	74.07	---
CON	280	10.9%	1	279.51	---
DI	30	1.2%	3	10.08	---
PVC	359	13.9%	2	179.43	---
Undetermined[(1)]	1,758	68.3%	22	79.93	---
Total	**2,575**	**100.0%**	**30**	**85.84**	**PS-114 Total**
PVC	2,340	99.4%	19	123.18	---
Undetermined[(1)]	15	0.6%	4	3.67	---
Total	**2,355**	**100.0%**	**23**	**102.40**	
CI	228	17.9%	1	228.36	---
Undetermined[(1)]	1,048	82.1%	12	87.37	---
Total	**1,277**	**100.0%**	**13**		**PS-116 Total**
DI	32	52.7%	1	31.84	---
Undetermined[(1)]	29	47.3%	2	14.28	---
Total	**60**	**100.0%**	**3**		**PS-117 Total**
DI	49	1.7%	3	16.43	---
PVC	2,815	97.5%	25	112.58	---
Undetermined[(1)]	23	0.8%	5	4.68	---
Total	**2,887**	**100.0%**	**33**		**PS-119 Total**
CI	114	2.5%	2	57.19	---
DI	2,991	64.4%	24	124.62	---
PVC	529	11.4%	4	132.18	---
Undetermined[(1)]	684	14.7%	9	76.01	---
VC	324	7.0%	3	107.89	---
Total	**4,642**	**100.0%**		**110.52**	**PS-120 Total**
PVC	1,140	85.0%	14	81.45	---
Undetermined[(1)]	202	15.0%	1	201.98	---
Total	**1,342**	**100.0%**		**89.49**	**PS-121 Total**
PVC	865	100.0%	13	66.52	---
Total	**865**	**100.0%**		**66.52**	**PS-122 Total**
ABS	53	0.6%	1	53.26	---

Representative Pipe Materials in Norfolk Sewersheds
Based on City of Norfolk GIS Database (as of 2003)

Type of Pipe Material	Total Length (ft)	Percent in Sewershed	Number of Reaches	Average Length per Reach (ft)	Pumping Station ID
CI	682	8.3%	2	341.19	---
Undetermined[1]	7,324	88.8%	43	170.32	---
VC	191	2.3%	1	191.20	---
Total	**8,251**	**100.0%**	**47**	**175.55**	**PS-124 Total**
Undetermined[1]	503	100.0%	5	100.59	---
Total	**503**	**100.0%**	**5**	**100.59**	**PS-125 Total**
Undetermined[1]	2,628	100.0%	16	164.27	---
Total	**2,628**	**100.0%**	**16**	**164.27**	**PS-126 Total**
Undetermined[1]	508	100.0%	5	101.69	---
Total	**508**	**100.0%**	**5**	**101.69**	**PS-127 Total**
Undetermined[1]	87	100.0%	1	87.24	---
Total	**87**	**100.0%**	**1**	**87.24**	**PS-128 Total**
PVC	564	90.8%	5	112.89	---
Undetermined[1]	57	9.2%	13	4.42	---
Total	**622**	**100.0%**	**18**	**34.55**	**PS-130 Total**
CI	821	5.6%	6	136.83	---
CON	526	3.6%	2	263.04	---
PVC	152	1.0%	4	37.94	---
Undetermined[1]	11,794	80.5%	54	218.40	---
VC	1,351	9.2%	5	270.22	---
Total	**14,643**	**100.0%**	**71**	**206.25**	**PS-131 Total**
DI	27	0.4%	3	9.08	---
PVC	6,371	90.6%	49	130.03	---
Undetermined[1]	632	9.0%	12	52.68	---
Total	**7,031**	**100.0%**	**64**	**109.86**	**PS-132 Total**
Total	**3,957,014**	**100.0%**	**7,031**	**562.81**	**Grand Total**

City of Norfolk, Virginia
Department of Utilities

Submission Checklist For Preliminary Engineering Report

_____1. Title Page requirements incorporated:
   a. Virginia registered Engineer's stamp, signature and date.
   b. Other SCAT requirements

_____2. Engineer's PER format consistent with City Guidance in Sewershed Investigation Guidance Manual.

_____3. PER submittal includes appropriate number of copies as set by Engineering Services Agreement.

_____4. Complete Appendices including:
   a. Conceptual Drawings
      i. Overall Plan
      ii. Existing Conditions Plan
      iii. Recommendation Plan
      iv. Pump Station Site Plan (for Site Plan Committee Review)
      v. Pump Station layout plans, sections and schematics
   b. Calculations for pump station projects

_____5. Transmittal Letter for PER indicates whether or not there is need for submitting to DEQ for separate approval.

_____6. Discrepancies or deviations from City Guidance are identified and justification provided

_____7. Problem Statement (from SSES and request for proposal) identified and clarified to establish objectives of sewershed investigation.

_____8. Preliminary findings of the City's SSES (updated by Utilities) are compared to results of the sewershed investigation and differences reconciled with the PER recommendations.

_____9. Evaluation of up-to-date existing conditions clearly documented including:
   a. SSO history
   b. Utilities GIS condition mapping
   c. SSES and other reports/projects
   d. As-builts and plans (design drawings, planimetrics, and intersection mapping)
   e. Pump station O&M data
   f. O&M Needs

_____10. Documentation of investigations and results of field reconnaissance provided.

_____11. Information on field investigations includes:
   a. Recommendations for further field investigations (Initial PER)
   b. Documentation on approach (establishment of needs and phasing), methodology and results
   c. Use of City standard forms for field work (manhole inspection and smoke testing)

   d. CCTV work using NASSCO standards and with compatible interface to Hansen IMS

_____12. Information provided for:
   a. Coordination with HRSD (through Utilities)
   b. Coordination with other agencies affected
   c. Permits ultimately required for construction (of recommended project)

_____13. Engineering analysis:
   a. Upstream and downstream sewershed considerations addressed and factored into engineering evaluations
   b. Flow development and capacity analysis:
      i. Basis of average daily flow (water use, flow metering, population and planning flows)
      ii. Peak flow determination
      iii. Critical reach evaluation
      iv. I/I Reduction evaluation for gravity system
      v. Hydraulic evaluation of system
   c. Development and analysis of alternatives, including cost estimates (project and life cycle as appropriate)
   d. Findings, conclusions and recommendations - adequate analysis provided to indicate how conclusions and recommendations were developed

_____14. Conceptual design included for recommended plan
   a. Bases of design for pump station and force mains
      i. Flows and velocities
      ii. Other disciplines (mechanical, structural, architectural, HVAC/odors, electrical and alarms & controls)
   b. Depth of sewers and rehabilitation methods
   c. Cost estimate provided with detailed breakdown
   d. Implementation plan with necessary phasing
   e. Identification of easements and other property requirements

_____15. PER indicates if financing for project is state grant or loan funded and addresses additional PER requirements accordingly.

I have reviewed this Checklist for accuracy and hereby certify that the Preliminary Engineering Report (PER) as submitted is in accordance with the latest City Standards, City Guidance Documents (Sewershed Investigation Guidance Manual and the Standard Design Criteria Manual), the State Sewerage Collection and Treatment Regulations, and other appropriate federal and local requirements. The PER has been reviewed for completeness and accuracy and is herewith submitted for approval.

_____P.E.___ _____
Signature Certificate Number

_____ _____
Name Date

_____

City of Norfolk, Virginia
Department of Utilities

Procedure for Obtaining Water Consumption Data
August 2004

General:

The Department of Utilities water and sewer billing is based on a UBIS database that is maintained by the Department of Information Technology (IT Department). The database includes water and sewer service location addresses and water consumption data for customers within the City limits and large water meter consumption outside of the City. The water and sewer bills are based on water consumption over the normal billing period in hundred cubic feet (CCF) and the rate structures for each type of service. The water and sewer service location addresses are in a "Dime" format, which is sometimes incompatible with the format used by the City GIS. The IT Department is in the process of implementing an upgraded billing system and the intention is that the utility service locations addresses will be compatible with the City GIS addresses. However, in the interim, because of address inconsistencies, water consumption requests will involve several data manipulation steps as discussed in the Data Request Procedure.

Data Request Procedure:

Step 1. Request water consumption data from the IT Department using the attached Water Consumption Data Request Form. The form provides a choice of the User Class to be included in the data request. The period of record desired is included on the form. In most cases the IT Department will provide the entire UBIS file, with only the requested data included, to the City GIS Coordinator.

Step 2. Request from the IT Department a record of water consumption by accounts with special addresses that do not fit a standard address system (e.g. "4 Main Plaza"), for the desired record period.

Step 3. Provide the City GIS Coordinator with an ESRI compatible "shapefile" containing the boundary of the area(s) where water consumption data is required. The GIS Coordinator will use customized address parsing software to convert the UBIS addresses to the City GIS address format. The GIS Coordinator will provide the water consumption data in one or both of the following formats as indicated on the Norfolk Water Consumption Request Form:

- An Excel file of water consumers within the boundary of the area(s) where data is requested.

- An ESRI compatible shapefile of all of the water consumption addresses in the City's UBIS system. The database attached to the shape file will include the types of data requested on the Water Consumption Data Request Form for the entire City (and/or meters outside the City as requested). The data requester can use an ESRI based GIS software to extract data from the Citywide database for specific areas or can open a copy of the database file using Microsoft Excel

Step 4. Data requester should determine if any of the special address accounts fall within the boundary of area(s) of interest using ESRI based or other geospacial software.

City of Norfolk
Water Consumption Data Request Form
(Based on Utility Billing Information System (UBIS))

Location/Sewershed: _____

Date Requested: _____ **Date Needed:** _____

Type of Data Requested:

User Class Codes	Description	Desired	
		Yes	No
A	Navy- Inside Norfolk		
B	Bulk		
C	Commercial		
F	Fire Protection		
I	Industrial		
K	City Of Chesapeake		
L	Lawn Meter		
N	Navy- Outside Norfolk		
O	City Of Norfolk		
R	Residential Norfolk		
V	City Of Virginia Beach (Master Meters)		
W	Raw (Craney Island, USN)		
Y	Residential VB Deduct (Camp Pendleton, State Of VA)		
Z	Residential Virginia Beach		

Data Format Needed:		Yes	No
1	Excel File		
2	ESRI Compatible Shapefile		

Other:		Yes	No
1	Provide Consumption for Special Addresses		

Period of Record desired: (Month - Year to Month - Year)

Beginning Month	Beginning Year	End Month	End Year

City of Norfolk, Virginia
Department of Utilities

Suggested Sewer Rehabilitation Design Decision Procedure

The following written procedure is to be used in conjunction with the attached decision logic flowchart. This flowchart considers many of the general elements involved in a sewer rehabilitation project and assists the Design Engineer in evaluating the feasibility of the various options. The user of this document should note that it is very difficult to generalize engineering design matters without endangering the final product. This document and the attached flowchart are not intended to replace sound engineering judgment. Engineers should consider the applicability of the contents of this document to specific projects and, based on the characteristics and requirements of the projects make the necessary adjustments as required. In choosing the most suitable pipe rehabilitation method the individual considerations presented below need to be evaluated comprehensively for site specific conditions.

1. **CCTV or Digital Imaging sewer inspection and evaluation.** In order to determine the condition of the existing sewer pipe, a detailed visual inspection is required. Inspections by personnel entry may be feasible in larger pipelines (48" and above). However, in most cases, personnel access into smaller sewer pipes is not feasible and not preferable due to the confined space and obvious safety and health issues. In these cases, CCTV or the newer digital imaging technology is the preferred method to visually inspect the pipe. Either of these techniques can be used to verify the structural integrity of the pipe, identify sources of infiltration, assess the condition lateral connections and pipe joints, and other features that may affect the integrity and flow characteristics of the pipe. The evaluation of the pipeline is generally rated according to the National Association of Sewer Service Companies (NASSCO) assessment guidelines.

2. **Structural Integrity.** The internal visual investigation will assist in determining several important design considerations, the most important of which is the structural condition of the pipe. Many of the trenchless techniques are not recommended if there are partial or full collapses of the existing pipe. In most cases, if there are partial or full collapses of the host pipe, pipe bursting or dig and replace are the preferred methods. The visual inspection can also determine if there are any major sags in the existing pipe due to poor bedding conditions or if there is adequate slope of the pipeline. Again, trenchless techniques generally cannot resolve major sags or poor slope conditions because they assume the form of the host pipe. Dig and replace is often the preferred (or only) method that can resolve these issues.

   Root intrusion, poor or offset joints, and poor lateral or manhole connections are other important defects to note and evaluate, which may affect the structural integrity of the overall collection system. These defects can generally be resolved with trenchless rehabilitation techniques.

3. **Flow Characteristics.** After the visual inspection of the pipe is completed, a hydraulic analysis of the collection system is recommended. The hydraulic analysis should consider whether the existing pipe is sufficient for current and projected flow conditions. In general, if the pipe requires 75% or more of its existing flow capacity, the improved flow characteristics of a rehabilitated pipe should be calculated. If the improved flow conditions of a rehabilitated pipe still indicate a need for 75% or more of the existing flow capacity, consideration should be given to upsizing the pipeline either through dig and replace or pipe bursting. If the analysis shows that the pipe size is sufficient but the diameter cannot be reduced, sliplining, Shotcrete, or other spray on liners that reduce the diameter are generally not feasible and can be eliminated from consideration.

4. **Service Connections.** The quantity and location of the service connections must be carefully considered. Numerous service connections and service connections that enter the main at odd angles can be time consuming and expensive to reconnect or rehabilitate robotically from inside the pipe. Some trenchless techniques – in particular sliplining and pipebursting - require the lateral connections to be reestablished by digging and replacing.

5. **Bends In Host Pipeline**. Any bends that may be present in the sewer line between manholes can make trenchless methods more difficult to successfully rehabilitate the pipe. Techniques such as CIPP, Fold and Form, cement mortar, and chemical and epoxy coatings may be used if the bend is not severe and the host pipe is in reasonably good condition. However, sliplining and pipebursting are not as flexible and generally not as effective even with minor bends in the pipeline. The higher cost and feasibility of these methods should be considered.

6. **Surface Access**. The accessibility of the host pipe is the next consideration. If the pipe is greater than 10 feet deep, issues such as higher cost and safety become limiting factors for the dig and replace option. If the pipe is not accessible from the surface, or the cost to access the pipe is too great (i.e. the pipe is located under a major thoroughfare with numerous utilities in the immediate vicinity that would require a lengthy road closure), the dig and replace method may be eliminated and consideration given to the trenchless techniques.

7. **Existing Utilities**. In most mature cities there may be numerous utilities in close proximity to the sewer main located in the right-of-way or utility easement. In areas with a large number of utility lines, it may not be feasible to dig and replace. Pipebursting may also be eliminated as an option if there is a chance the vibration may affect the surrounding utilities.

8. **Bypass pumping**. Nearly all the techniques to rehabilitate sewer pipelines require some level of bypass pumping or flow diversion to be successful. Some techniques, such as dig and replace and sliplining can be properly installed with a small degree of flow in the collection system. However, other techniques such as

CIPP, Fold and Form, and pipebursting generally require, and result in a better-finished product, if there is no flow in the pipeline. For this reason, the feasibility of bypass pumping is an important aspect to consider.

9. **Access Pit**. Some trenchless techniques do require some surface disruption at each or one end of the line to be rehabilitated, typically at the manhole locations. Sliplining and pipebursting both require access pits, while the other techniques can be performed through an existing or new manhole. Consideration must be given as to whether the existing site will allow an access pit because of traffic and pedestrian impacts, location of the manhole, and location of existing facilities. If an access pit is not feasible, sliplining and pipebursting can generally be eliminated as options.

10. **Existing Soil Conditions.** Pipebursting is one trenchless technique that may have an impact on the surrounding utilities and surrounding soil. If a sewer is less than four feet deep and/or constructed in poor soil that is not conducive to tunneling or vibrational impacts, pipebursting may not be a feasible choice.

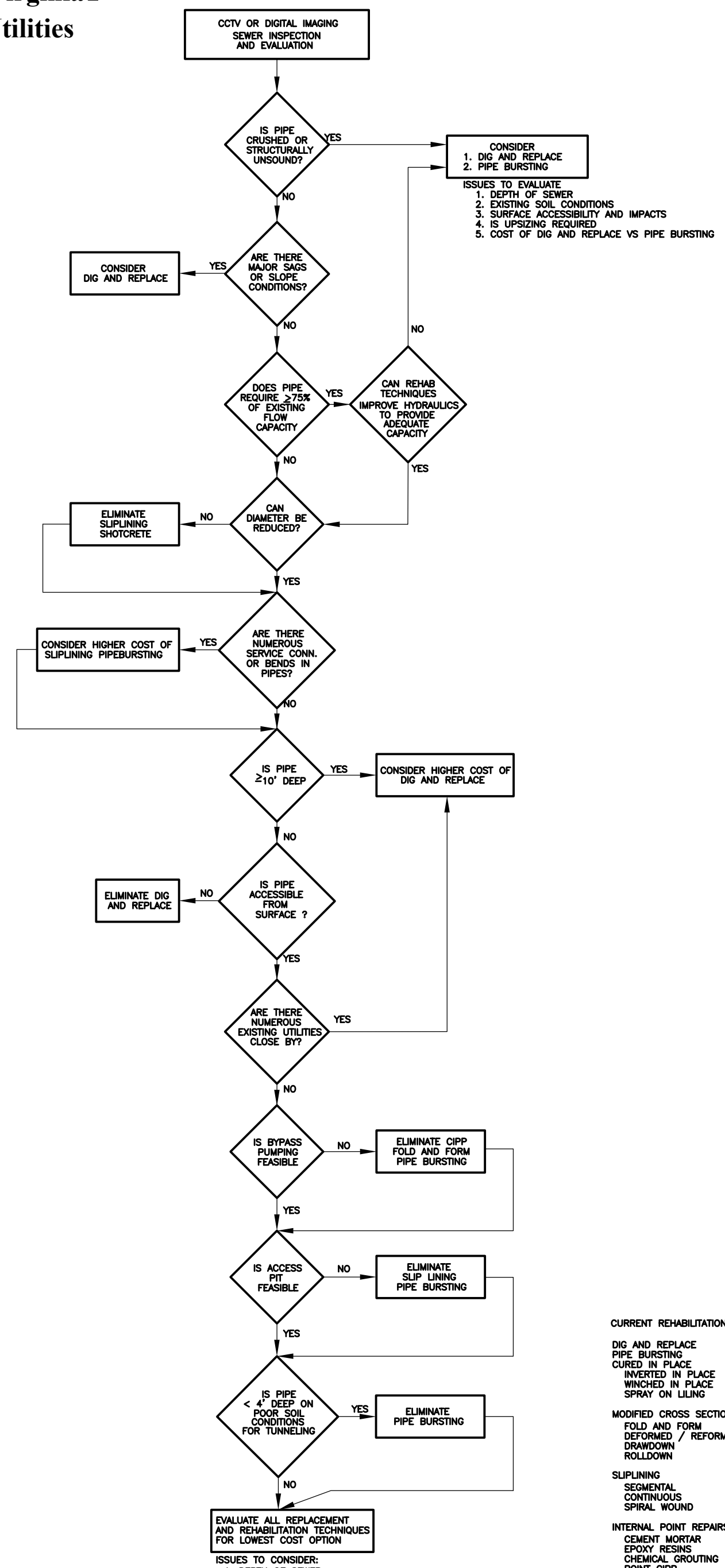
11. **Other issues to consider.** After the visual pipe inspection, hydraulic analysis, and site conditions are considered; a decision can be made as to what will provide the best value and best service for the longest period of time. A cost benefit analysis can be done evaluating each of the various methods of sewer rehabilitation. Factors to consider include, but are not limited to:

    a. Depth of sewer
    b. Size of pipe
    c. Site access
    d. Impacts from surface disruptions (both financial impacts and "good neighbor" impacts)
    e. Time required for bypass pumping or flow diversion
    f. Quantity and method of service reestablishment
    g. Experience and availability of local contractors to perform each method

Decision. The final decision will be based on what provides the greatest value to the overall collection system at the least cost. Some situations may require a combination of several methods. For example, a pipe with numerous leaky joints and one partial collapse may require a dig and replace point repair at the partially collapsed section before sliplining the entire pipe. Regardless of the rehabilitation technique that is ultimately chose, each situation must be evaluated systematically using a procedure similar to the outline herein to determine the best engineering solution. The following table is a comparison of the various sewer rehabilitation methods:

COMPARISON OF TRENCHLESS METHODS

Method	Advantages	Disadvantages
CIPP	Can go over irregularities	Bypass or diversion of flow required
	Durable	Must allow adequate curing time
	Good at reducing I/I	Defective installation may be difficult to rectify
	Superior flow characteristics	Reduces pipe diameter
	High corrosion resistance	Cannot increase size
Modified Cross Section	Can go over irregularities	Bypass or diversion of flow required
	Good at reducing I/I	The cross section may shrink or unfold after expansion
	Superior flow characteristics	Reduces pipe diameter
	High corrosion resistance	Infiltration may occur between liner and host pipe unless sealed
	Less expensive than CIPP	Liner may not provide adequate structural support
		Defective installation may be difficult to rectify
Pipe Bursting	Can go over irregularities	Bypass or diversion of flow required
	Can increase size	Insertion pit required
	Good at reducing I/I	Percussive action can cause significant ground movement
	Superior flow characteristics	May not be suitable for all materials
	High corrosion resistance	Non-reinforced pipe only
		Major impact to laterals - generally requires open cut
		Does not address pipe sags or slope deficiencies
Sliplining	Good at reducing I/I	Insertion pit required
	Superior flow characteristics	Reduces pipe diameter
	High corrosion resistance	Not well suited for small diameter pipes
		Infiltration may occur between liner and host pipe unless sealed
		Major impact to laterals - generally requires open cut
		Difficult to vary alignment
		Difficult to grout annular space



SEWER REHABLILTATION DECISION FLOWCHART

City of Norfolk, Virginia
MANHOLE INSPECTION FORM

Appendix F(1)

MHID#:

Address:

Start Date/Time: (MM/DD/CCYY)

Complete Date/Time:

Completed By:

Crew:

Project:

Crew Leader:

Weather
- ☐ 20s ☐ 60s
- ☐ 30s ☐ 70s
- ☐ 40s ☐ 80s
- ☐ 50s ☐ 90s

◉ Foggy ◉ Rainy
◉ Night ◉ Sunny
◉ Overcast

Location:
- ☐ Asphalt Rd/Alley in Crown
- ☐ Asphalt Rd/Alley in Gutter
- ☐ Concrete Rd/Alley in Crown
- ☐ Concrete Rd/Alley in Gutter
- ☐ Paved Over/Not Accessible
- ☐ Sidewalk
- ☐ Dirt/Grass
- ☐ Other

- ☐ Ability to Quantify
- ☐ Drop Manhole
- ☐ Metered Manhole
- ☐ Surcharge Evidence
- ☐ Debris/Silt Buildup

Evid. Depth (ft):
Flow Depth:
Buildup Depth (ft):

Manhole Cover/Lid

Cover Diameter (inches):

Condition	Leakage (GPM)	Cover Type	# Cover Holes	Hole Diam.
☐ Good	☐ <0.1	☐ Bolted	☐ None	☐ 1/4
☐ Fair	☐ 0.1-0.5	☐ Gasket	☐ 1 to 5	☐ 1/2
☐ Bad	☐ >0.5	☐ Locked Down	☐ 6 to 10	☐ 3/4
		☐ Standard	☐ 11 to 15	☐ 1
		☐ Watertight	☐ 16 to 20 ☐ >20	☐ 1 1/4

- ☐ Ponding Around MH
- ☐ Is Ponding a Problem?
- ☐ Insert Installed?
- ☐ Dust Cover?
- ☐ Subject to Sheet Flow?
- Sheet Flow Area (sqft):

Inches (+/-) Grade
- ☐ + Plus
- ☐ - Minus

◉ 0 ◉ 1 ◉ 2 ◉ 3 ◉ 4 ◉ 5 ◉ 6 ◉ >6

Observed Conditions
- ☐ Broken ☐ Cracks ☐ Debris ☐ Mud on Cover ☐ No Handle

Manhole Frame

Condition	Material	Leakage(GPM)	Leak Evidence	Observed Conditions
☐ Good	☐ Cast Iron	☐ <0.1	☐ Mud	☐ Cracked
☐ Fair	☐ Other	☐ 0.1 - 0.5	☐ Rust	☐ Roots
☐ Bad		☐ >0.5	☐ Wetness	

- ☐ Defective Frame to MH Seal?
- Offset from MH (inches):

Paving Adjustment Ring

◉ None ◉ 1 ◉ 2 ◉ 3 ◉ 4 ◉ 5 ◉ 6 ◉ >6

Grade Adjustment Ring

☐ Grade Adjustment Ring?

Condition	Material	Leakage (GPM)	Leak Evidence	Observed Conditions
☐ Good	☐ Block	☐ <0.1	☐ Mud	☐ Broken
☐ Fair	☐ Brick ☐ Precast	☐ 0.1-0.5	☐ Rust	☐ Holes
☐ Bad	☐ Parged Over	☐ >0.5	☐ Wetness	☐ Roots

Height (inches): # Courses: Offset (inches):

Manhole Type (Cone Type and Wall Material)

◉ Concentric	☐ Block	☐ Poured-in-Place
◉ Eccentric	☐ Brick	☐ Precast
◉ Flat Top	☐ Parged Over	☐ Shotcrete

Cone

Condition	Material	Leakage (GPM)
☐ Good	☐ Block ☐ Precast ☐ Poured-in-Place	☐ <0.1
☐ Fair	☐ Brick ☐ Shotcrete ☐ None	☐ 0.1-0.5
☐ Bad	☐ Parged ☐ Unknown	☐ >0.5

Observed Conditions
- ☐ Cracks ☐ Debris ☐ Deteriorated ☐ Holes ☐ Roots ☐ Needs Cleaning

Steps

# of Steps:
- ☐ Corroded How Many?:
- ☐ Missing How Many?:

Condition	Material	Leakage (GPM)
☐ Good	☐ Aluminum ☐ Rubber/Plastic	☐ <0.1
☐ Fair	☐ Brick ☐ Unknown	☐ 0.1 - 0.5
☐ Bad	☐ Cast Iron	☐ >0.5

Leak Evidence ☐ Mud ☐ Rust ☐ Wetness

Wall

Barrel Diameter (ft):

Condition	Material		Leakage (GPM)
☐ Good	☐ Block	☐ Precast	☐ <0.1
☐ Fair	☐ Brick	☐ Shotcrete	☐ 0.1-0.5
☐ Bad	☐ Parged Over	☐ Unknown	☐ >0.5
	☐ Poured-in-Place	☐ None	

Observed Conditions
- ☐ Cracks ☐ Deteriorated ☐ Roots
- ☐ Debris ☐ Holes ☐ Needs Cleaning

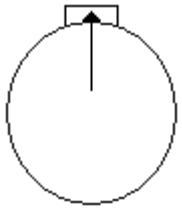
Bench

Condition	Material	Leakage (GPM)	Observed Conditions
☐ Good	☐ Brick	☐ <0.1	☐ Cracks
☐ Fair	☐ Concrete	☐ 0.1-0.5	☐ Debris
☐ Bad	☐ Parged	☐ >0.5	☐ Deteriorated
	☐ Precast		☐ Holes
	☐ Unknown		☐ Roots
			☐ Needs Cleaning

Channel

Condition	Material			Leakage (GPM)	Observed Conditions	
☐ Good	☐ Brick	☐ HDPE	☐ PVC 1/2 Pipe	☐ <0.1	☐ Cracks	☐ Holes
☐ Fair	☐ Concrete	☐ Lining	☐ VCP 1/2 Pipe	☐ 0.1 - 0.5	☐ Debris	☐ Roots
☐ Bad	☐ Concrete/VCP	☐ Parged Over	☐ Unknown	☐ >0.5	☐ Deteriorated	☐ Needs Cleaning
	☐ 1/2 Pipe	☐ Precast				

Connecting Pipeline(s)



	Clock	Size	Type
Influent			
Effluent			

Possible Utility Lines Passing through Manhole

Size: Depth: Other:

Comments:

City of Norfolk, Virginia
Department of Utilities

Appendix F(2)

Smoke Testing Observation Form

COVER SHEET

Setup #:

Activity:

Length:

Upstream Asset ID:

Type:

☐ Sewer MH ☐ Sewer Node
☐ Sewer Misc. ☐ Sewer Value

Downstream Asset ID:

Type:

☐ Sewer MH ☐ Sewer Node
☐ Sewer Misc. ☐ Sewer Value

Start Date/Time:

Completed Date/Time:

Completed By: **Project:**

Crew: **Crew Leader:**

Neighborhood: **Map#:**

Weather:

☐ 40s ☐ 60s ☐ 80s ◯ Foggy ◯ Overcast ◯ Sunny
☐ 50s ☐ 70s ☐ 90s ◯ Night ◯ Rainy

Surface Cover:

☐ Asphalt ☐ Concrete
☐ Brick ☐ Grass/Lawn ☐ Other _____

☐ **History**

☐ **Plug or Sandbag Upstream?** ☐ **Plug or Sandbad Downstream?** **I/I Factor:**

☐ **Blower Upstream?** ☐ **Blower Downstream?** **Infiltration:**

Other Leaks Not Noted:

Field Inspection Test Results:

City of Norfolk, Virginia
Department of Utilities

Appendix F (2)

Smoke Testing Observation Form

OBSERVATION SHEET

Setup #:

Defect #:

Upstream Asset ID:

Type:
- ☐ Sewer Manhole
- ☐ Sewer Node
- ☐ Sewer Misc.
- ☐ Sewer Value

Downstream Asset ID:

Type:
- ☐ Sewer Manhole
- ☐ Sewer Node
- ☐ Sewer Misc.
- ☐ Sewer Value

Surface Cover:
- ◯ Asphalt
- ◯ Brick
- ◯ Concrete
- ◯ Grass/Lawn
- ◯ Other _____

Source:
- ☐ Cleanout
- ☐ Pipe
- ☐ Downspout
- ☐ Roof Vent
- ☐ Drain
- ☐ Swale/Ditch
- ☐ Inlet
- ☐ None Apparent
- ☐ Manhole
- ☐ Other _____

Type:
- ☐ Building
- ☐ Lateral
- ☐ Communications
- ☐ Mainline
- ☐ Electric
- ☐ Storm
- ☐ Gas
- ☐ N/A
- ☐ Houseline
- ☐ Other _____

Building #:

Street Name:

Street Direction: ◯ N ◯ S ◯ E ◯ W

Street Suffix:

Sub-Designation:

Zip Code:

I/I Estimate (GPM):

Distance from Upstream MH (ft):

Distance from Left of Main (ft):

Distance from Right of Main (ft):

# of Photographs

Photograph Name:

Photograph Name:

Photograph Name:

Comments:

City of Norfolk, Virginia
Department of Utilities

Appendix F (2)

Smoke Testing Observation Form

SKETCH SHEET

Date:

Setup #:

Defect #:

Upstream Asset ID:

☐ Sewer Manhole ☐ Sewer Node
☐ Sewer Miscellaneous ☐ Sewer Value

Downstream Asset ID:

☐ Sewer Manhole ☐ Sewer Node
☐ Sewer Miscellaneous ☐ Sewer Value

Building #:

Street Direction:
(where applicable)
○ N ○ S ○ E ○ W

Street Name:

Street Suffix:

Sub-Designation (Apt#):

Zip Code:

Comments/Sketch:

City of Norfolk, Virginia
Department of Utilities

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:
Weather:	

Table of Contents

Station Type

☐ Conventional ☐ Submersible ☐ Pneumatic Ejector
☐ Package (can) ☐ Suction Lift ☐ Other:

General Site Conditions/Aesthetics

A	**General**	
	Site Size	
	Constrainments to Site	
	Distance to Water Body	
	Type of Area	
	Overflow Evidence	
	Vacant Land Next to Site	
	Other	
B	**Landscape & Grounds**	
	General Appearance	
	Trees and Shrubs	
	Screening Adequacy	
	Animals	
	Other	
C	**Pavement**	
	Type	
	Condition	
	Other	
D	**Vehicular Access**	
E	**Drainage**	
	Standing Water	
	Flooding Potential	
	Drainage across pavement	
	Inflow	
	Other	
F	**Odors and Noise**	
G	**Housekeeping**	

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:
Security and Safety	
A Security	
Fence/Gate	
Doors & Locks	
Hatches	
Site Lighting	
Alarm System	
Local Alarms	
B Safety	
Hazard Notices Posted	
LOTO in use	
Wet floors	
Trip/Bump Hazards	
Electrical Hazards	
Ventilation	
Equip. guards removed	
Room to work on Equip.	
Other	
C Chemical Storage	
Chemicals on-site	
Proper Handling/Storage.	
MSDS on-site	
Other	
Superstructure	
A Walls	
Type	
Structural Conditions	
Rodent/Insect inhabit.	
Leaks	
Clean	
Corrosion/Paint	
Ventilation	
Penetrations	
Other	
B Roof	
Type	
General Condition	
Structural Conditions	
Rodent/Insect inhabit.	
Leaks	
Clean	
Corrosion/Paint	
Penetrations	
C Entry	
Type	
Structural Conditions	
Safety	

City of Norfolk, Virginia
Department of Utilities

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:
Corrosion/Paint	

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:

Wet Well	
A Inventory	
Dimensions	
Liner Type	
Level Controls Type	
Back-up Controls Type	
Bypass Piping	
Entry Type (Ladder)	
Barscreen	
Confined Space Hoist	
B History	
High Water Level	
History of Maintenance	
History of Odors	
History of Overflows	
C Walls	
Grease & Rags	
Sand	
Laitenance (Chalking)	
Spalling	
Cracks	
Aggregate Exposed	
Rebar Exposed	
D Ceiling	
Laitenance (Chalking)	
Spalling	
Cracks	
Aggregate Exposed	
Rebar Exposed	
Other	
E Equipment Access	
Access Hatch Condition	
Ladder/Railing Condition	
Davit Crane	
Pump Rails	
F Miscellaneous	
Level Controls Condition	
Bypass Piping Condition	
Bypass Pump Connect.	
Ventilation Condition	

Pumping Station Inspection Form

Station Name:			
Address:			
Inspection Date:		Inspection Time:	
Dry Well			
A Dry Well Size			
B Pump Inventory	#1	#2	#3
Make			
Model			
Type			
Impeller Diameter			
Maximum Impeller Dia.			
Seal Type			
Design Capacity Q (gpm)			
Design Head - H (ft)			
Other			
C Motor Inventory			
Make			
Model			
Type			
RPM			
Horsepower			
Nominal Efficiency			
Other			
D Supplemental Info			
Seals and Bearings			
Noise and Vibration			
Foundations/Supports			
Cavitation			
Lubrication			
Accessibility			
Date Motor Rewound			
Problems With Motors			
Pump Upgrade Date			
Problems With Pumps			
Pump Curve Available			
Other			
E Piping and Valving			
Valve Operator Type			
Exercised			
Disch/Suction full open			
Corroded bolts			
Leaking			
Valve Maintenance			
Check Valve perform.			
Other			

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:

Dry Well (Continued)	
F Shafts	
Seals and Bearings	
Noise and Vibration	
Harmonics	
Foundations/Supports	
Replacement Date	
Why Replaced	
Bearing Life	
G Paint and Corrosion	
Condition of Wall Coating	
Condition of Floor Coating	
Corrosion/Cond. of Metalics	
H Leaks	
Ceiling	
Ceiling penetrations	
Other	
I Walls	
Laitenance (Chalking)	
Spalling	
Cracks	
Aggregate Exposed	
Rebar Exposed	
J Access	
Stairway/Ladder Type	
Condition	
K HVAC and Lighting	
Ventilation Condition	
Ventilation Control Type	
Dehumidification Condition	
Unit Heaters Condition	
Lighting Condition	
Sump Pump Condition	
Other	

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:

Electrical, Controls, and Instrumentation		
A	**Inventory**	
	Flow Meter	
	Pressure Gauge	
	Level Sensor	
	Recorders	
B	**Motor Controls**	
	Clean	
	Rodent/Insect inhabit.	
	Leaks (Outdoor encl)	
	Dry/Brittle wire insul.	
	Other	
C	**Circuit Breakers**	
	Manufacturer	
	Age	
	Condition	
D	**Starter Controls**	
	Manufacturer	
	Type	
	Condition	
E	**Alarms/SCADA/ Instrumentation**	
	Vendor/System Suppier	
	Age	
	Condition	
D	**Variable Speed Drive**	
	Manufacturer/Model	
	Age	
	Condition	
	Excessive Heat	

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:

Miscellaneous		
A	**Records**	
	Station logs	
	O&M manuals	
	Emergency procedures	
	PM schedules and info	
	Other	
B	**Odors/Control Meas.**	
	Type	
	Age	
	Capacity	
	Condition	
C	**Recordings**	
	Run hours (ea. pump)	
	Flow and head	
	Other	
D	**Potable Water Supply**	
	Source	
	Backflow Preventor Type	
E	**Seal Water Supply**	
	System Type	
	Capacity	
	Head	

City of Norfolk, Virginia
Department of Utilities

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:

Emergency Generator		
A	**Inventory**	
	Make/Model	
	Generator Size	
	Age/Hours	
	Load Transfer Switch Manufacture	
	Model	
	Type	
	Fuel Type	
	AST Volume	
	AST Containment Size	
B	**Condition**	
	Generator Condition	
	Noise	
	Exhaust	
	AST Condition	
C	**KVA Requirement for Station**	
Emergency Pump		
A	**Inventory**	
	Make/Model	
	Pump Size	
	Pump Head	
	Age/Hours	
	AST Volume	
	AST Containment Size	
B	**Condition**	
	Pump Condition	
	Noise	
	Exhaust	
	AST Condition	
C	**Requirements for Station**	
	Pump Design Capacity	
	Pump Design Head	

City of Norfolk, Virginia
Department of Utilities

Pumping Station Inspection Form

Station Name:	
Address:	
Inspection Date:	Inspection Time:

Reported Problems	
Odors	
Water Hammer	
Vibration/Noise	
Cavitation	
Frequent Repairs	
Power Outage/ Generator Performance	
Break-in/Vandalism	
SCADA and Controls Performance	
Pump Controls Performance	
Wet Weather/I&I Problems	
Other	

City of Norfolk, Virginia
Department of Utilities

Measurement Payment Items
(Periodically Updated)

Table of Contents

WATER ITEMS

SELECT BACKFILL:

Measurement for this item will be based upon the DAILY presentation of delivery tickets to the Inspector. **Without exception, delivery tickets must be given to the Inspector on a daily basis and will NOT be accepted with monthly invoices.** Select backfill will be measured and paid for by the **CUBIC YARD** at the established price of $15.00 per cubic yard.
The Engineer shall approve select backfill such as borrow sand or other common granular fill hauled to the job site for use.

A delivery ticket shall accompany each load of select backfill material. Each ticket will be serially numbered, list the company supplying the fill material, truck number delivering material, date, size of load, and the project where delivered. In the event a material delivery ticket and delivery do not correspond, the Engineer may refuse the delivery and / or payment until such conditions are corrected to the satisfaction of the Engineer. Payment shall include proper disposal of surplus material removed.

The Contractor shall designate the source of material and provide appropriate data as part of the submittal process.

SELECT BEDDING, No. 57 STONE:

Measurement for this item, when properly installed will be based upon the DAILY presentation of delivery tickets to the Inspector**. Without exception, delivery tickets must be given to the Inspector on a daily basis and will NOT be accepted with monthly invoices.** Select bedding, No. 57 stone, will be measured and paid for by the **TON** at the established price of $18.00 per ton.

The Contractor shall designate the source of material and provide appropriate data as part of the submittal process. The Engineer shall approve select bedding material hauled to the job site for use.

Payment will only be made for special bedding used during the installation of pipe work and will not be paid for when used in lieu of proper dewatering methods, as determined by the Engineer. Special bedding required for the installation of manholes, fire hydrants and where otherwise shown on the drawings will not be measured for payment as such, its' costs shall be included in the unit prices bid for those items.

A delivery ticket shall accompany each load of select bedding material. Each ticket will be serially numbered, list the company supplying the fill material, truck number delivering material, date, size of load, and the project where delivered. In the event a material delivery ticket and delivery do not correspond, the Engineer may refuse the delivery and / or payment until such conditions are corrected to the satisfaction of the Engineer. Payment shall include proper disposal of surplus material removed.

SHEETING LEFT-IN-PLACE:
Timber sheeting as described in the drawings, specifications or as directed by the Engineer to be left in place, shall be measured for payment based upon total **THOUSAND BOARD FEET** of measure. Payment will be made at the unit price established under the "Schedule of Prices".

PVC WATER MAIN:
Pipe shall be measured horizontally along the centerline of the main from the centerline at the point of connection(s), or to the centerline of the plug at dead ends, without deduction for in-line valves or fittings for all pipes noted on the plans or as directed by the Engineer. Pipe shall be measured based on the **LINEAR FEET** of pipe installed, by size. Pipe in place will be paid for at the unit price(s) bid.

Included in the cost is furnishing and installing the pipe, complete and in place. Included in the cost will be dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, thrust protection, backfilling and compaction. Additionally the on site temporary storage and drying of trench soils is also included. Also included are cleaning, flushing, testing, disinfecting, neutralization of disinfecting agent, # 10 gauge copper wire and non-metallic marking tape (copper tracer wire will be checked for continuity at or prior to final inspection). The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. With the exception of permanent paving, all right of way restoration and related landscaping shall be incorporated in this item.

No payment, partial or final, shall be made for any part of a water distribution system until that part of the system has been flushed, tested, disinfected and placed into service. (Service lines shall be transferred to the new system immediately upon activation of that system, or when deemed appropriate by the Engineer).

DUCTILE IRON WATER MAIN:
Pipe shall be measured horizontally along the centerline of the main from the centerline at the point of connection(s), or to the centerline of the plug at dead ends, without deduction for in-line valves or fittings for all pipes noted on the plans or as directed by the Engineer. Pipe shall be measured based on the **LINEAR FEET** of pipe installed, by size. Pipe in place will be paid for at the unit price(s) bid.

Included in the cost is furnishing and installing the pipe complete and in place. Dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, thrust protection, backfilling and compaction are included items. Additionally, on site temporary storage and drying of trench soils are included. Cleaning, flushing, testing, disinfecting, neutralization of disinfecting agent, the removal, proper disposal and complete joint to joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. With the exception of permanent paving, all right of way restoration and related landscaping shall be incorporated in this item.

No payment, partial or final, shall be made for any part of a water distribution system until that part of the system has been flushed, tested, disinfected and placed into service. (Service lines shall be transferred to the new system immediately upon activation of that system, or when deemed appropriate by the Engineer).

TAPPING SLEEVE AND VALVE:

Measurement for payment shall be based on the number of **EACH** installed, by size, complete and in place. Included in the cost is furnishing and installing the required tapping sleeve and resilient seat tapping valve, excavation, fittings, testing, tapping, backfilling, valve box and valve extension (if required) complete and in place. Included in the costs will be the furnishing and placement of an appropriately sized riser (riser material shall match type of pipe installed), Norfolk standard valve box and lid, set to grade. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

GATE VALVE:

Measurement for this item will be based on the number of **EACH** gate valve installed, by size.

All gate valves in the water system shall be resilient-seat gate valves that open to the right. All valves will be operated (fully opened and fully closed) in the presence of the Inspector prior to installation.

The unit price bid for this item shall include all costs of furnishing and installing the valve (and valve extensions, if required), complete and in place. Included in the costs will be the furnishing and placement of an appropriately sized riser (riser material shall match type of pipe installed), Norfolk standard valve box and lid, set to grade. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

DUCTILE IRON FITTINGS:

Measurement for this item will be based on the number of **EACH** ductile iron fitting installed.

Fittings included in this bid item are tees (with the exception of tees for fire hydrants, which will be paid for under the fire hydrant pay item), bends, crosses and reducers including all accessories and thrust protection, complete and in place. The cost of providing any other items that may be commonly referred to as a fitting shall be included in the cost of the pipe.

Included in the unit cost of ductile iron fittings are all costs of providing and installing ductile iron fittings, complete and in place including MEGA LUGS and restraint to the proper pipe length. Also included are excavation, bedding, backfill, compaction, dewatering, erosion and sediment control, traffic control, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping is also included.

FIRE HYDRANT:

Measurement for this item will be based on the number of **EACH** fire hydrant installed. Fire hydrants shall be manufactured in accordance with AWWA Specification C502, latest revision. The fire hydrant shall be installed with MEGA LUG retainer glands. All valves controlling the fire hydrant shall be resilient seat gate valves and will be installed with tie rod assemblies to the main line tee on the water main. The water main between the fire hydrant and the main line tee shall be ductile iron (minimum class 51).

Included in the unit cost of the fire hydrant are all costs of providing and installing 4 ½" fire hydrants complete and in place, including MEGA LUGS, all fittings from and including the main line tee to the hydrant, tie rod restraint and thrust protection. Also included are excavation, bedding, backfilling, compaction, dewatering, erosion and sediment control, traffic control, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, sheeting and / or shoring in accordance with OSHA regulations, temporary pavement patching and permanent pavement replacement. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping is also included.

The 6" ductile iron main, valve, and tapping sleeve and valve (if required) will be paid for under their respective unit prices.

BLOW-OFF VALVES:

Measurement for this item will be based on the number of **EACH** blow-off valve installed.

The unit price bid for this item shall be full compensation for the furnishing and installing of blow-off valves complete and in place. Included in the costs will be the furnishing and placement of a standard blow-off valve box and lid, set to grade. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

SERVICE SADDLE:

Measurement for this item will be based on the number of **EACH** service saddle installed.

The unit price bid for this item shall be full compensation for the furnishing and installing service saddles complete and in place. Service saddles will only be used on mains that are less than 6" in diameter, unless otherwise directed by the Engineer.

Also included are excavation, sheeting and/or shoring in accordance with OSHA regulations, bedding, backfill, compaction, dewatering, erosion and sediment control, traffic control, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching and permanent pavement replacement. The removal, proper disposal and complete joint-to-

joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping are also included.

CORPORATION STOPS:

Measurement for this item will be based on the number of **EACH** corporation stop installed.

The unit price bid for this item shall include all costs of furnishing and installing the corporation cock complete and in place. This shall include but not be limited to tapping the main, installing the corporation stop and connecting the service line to the corporation cock. Also included are dewatering, erosion and sediment control, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

TYPE K, COPPER TUBING (PUBLIC SERVICE):

Pipe shall be measured horizontally along the centerline of the service from the centerline of the main to the meter stop / copper connection. Tubing shall be measured based on the **LINEAR FEET** of tubing installed. Tubing, complete and in place, will be paid for at the unit price(s) bid.

Included in the cost is furnishing and installing the copper service lines located within the City's right of way. Also included are erosion and sediment control, tree protection, traffic control, excavation, clearing, grubbing, grading, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement patching and permanent pavement replacement. Dewatering, clearing, grubbing, grading, boring or jacking, backfilling and compaction are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item. **No open cuts for service lines will be allowed unless authorized by the engineer prior to the service installation.**

No payment shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

METER STOPS / COPPER CONNECTIONS:
Measurement for this item will be based on the number of **EACH** meter stop / copper connection installed.

The unit price bid for this item shall include all costs of furnishing and installing the meter stop / copper connection complete and in place. This shall include, but not be limited to, connecting new or existing service lines, all copper couplers or meter stops, inspecting the service line on both sides of the meter for lead connections and / or lead pipe.

Also included are dewatering, erosion and sediment control, traffic control, excavation, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

METER BOX:
Measurement for this item will be based on the number of **EACH** meter box installed.

The unit price bid for this item shall be full compensation for furnishing and installing a Norfolk standard meter box and lid complete and in place, and set to grade. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

METER BOX RELOCATION:
Measurement for this item will be based on the number of **EACH** meter box relocated.

The unit price bid for this item shall be full compensation for connecting to and tracing the private service line, safe removal, transport and replacement of the existing meter box to grade. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter,

sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

The Contractor shall replace meter boxes and/or meter box lids damaged or lost during removal and / or transport, with a new meter box at no additional cost to the City.

TYPE K, COPPER TUBING (PRIVATE SERVICE):

Pipe shall be measured horizontally along the centerline of the service from the meter stop / copper connection to the point of connection at or near the house or plumbing turn-around. Tubing shall be measured based on the **LINEAR FEET** of tubing installed.

Included in the cost is furnishing and installing the copper service lines located on private property. Erosion and sediment control, dewatering, care and protection of existing utilities and structures, tree protection, excavation, clearing, grubbing, grading, connection at or near the house, and backfilling are included items. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. This item shall be used to replace lead service lines on private property if necessary.

A licensed plumbing contractor shall perform all plumbing work.

No payment shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

PLUMBING PERMIT ALLOWANCE:

Measurement for this item will be based on the number of **EACH** plumbing permit obtained. (The amount of **$40.65** is established as the cost of the permit ($35.35) plus 15% for overhead and profit.)

This pay item shall be full reimbursement for all obtained plumbing permits for the replacement of water service lines on private property. The Contractor shall be reimbursed for the actual number of permits obtained as evidenced by the receipts submitted to and approved by the Engineer. Receipts shall be submitted with monthly invoices.

PLUMBING REPAIR ALLOWANCE:

Measurement for this item will be based on the **ACTUAL COST** of the minor plumbing repair work on private property.

This pay item shall be full reimbursement for minor plumbing repair work on service lines on private property. Payment under this item shall be made only when the defect is determined to be "pre-existing" and the Engineer has authorized the repair work in writing prior to execution of the repair work. All necessary landscape restoration shall be included in the costs.

CUT AND CAP EXISTING WATER MAIN:

Measurement for this item will be based on the number of **EACH** cut and cap performed.

As part of the abandonment process, portions of the existing water distribution system will be separated from the new system. Valves will be closed, mains will be capped, and non-pressurized mains will be brick and mortar plugged, valve-operating nuts will be removed, and valve boxes and fire hydrants will be removed. This pay item is full compensation for the cutting and capping of existing water mains.

This item shall include all costs of furnishing and installing pressurized caps on existing water mains within three feet of existing valves and restraint of pressurized caps to valves or other fittings to remain on the system. The price also includes sealing the adjacent open end of the non-pressurized abandoned main with a brick and mortar plug.

Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, thrust protection, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

After cuts and caps have been performed, the Contractor shall assist the Inspector in opening hydrants along the abandoned portion of the main to assure that the main has been properly abandoned. All cuts and caps shall be verified by the Inspector prior to the Contractor performing any backfilling. Any cut and cap excavations that are backfilled prior to verification will be subject to re-excavation and backfilling by the Contractor at no additional cost to the City.

VALVE ABANDONMENT:

Measurement for this item will be based on the number of **EACH** valve abandoned.

As part of the abandonment process, portions of the existing water distribution system will be separated from the new system. Valves will be closed, mains will be capped, and non-pressurized mains will be brick and mortar plugged, valve-operating nuts and valve boxes will be removed. This pay item is full compensation for the valve abandonment.

The valve abandonment shall include the intact and undamaged removal of the existing valve box and lid, safe transport and delivery of valve box and lid to the Water Distribution Yard where a receipt must be obtained for the delivery of valve boxes. The removal of the valve operating nut and its' delivery to the on site Inspector is required. Also included are dewatering, erosion and sediment control, tree protection, backfill and compaction, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

The Contractor shall replace valve boxes and / or lids damaged or lost during removal and / or transport, with a new valve box and / or lid at no additional cost to the City.

FIRE HYDRANT REMOVAL:

Measurement for this item will be based on the number of **EACH** fire hydrant removed.

Fire hydrant removal shall include the excavation, the intact and undamaged removal of the entire fire hydrant and barrel assembly and safe transport and delivery of the fire hydrant to the Water Distribution Yard where a receipt must be obtained, backfilling and compaction. The price also includes sealing the open end of the non-pressurized fire hydrant main with a brick and mortar plug. Included in the unit cost are dewatering, erosion and sediment control, traffic control, pavement removal and proper disposal, backfilling, clearing, grubbing, grading, care and protection of existing utilities and structures, sheeting and / or shoring in accordance with OSHA regulations, temporary pavement patching and permanent pavement replacement. Also included are the removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping is also included.

The Contractor shall replace fire hydrants damaged or lost during removal and / or transport, with a new fire hydrant at no additional cost to the City.

The Contractor shall replace valve boxes and / or lids damaged or lost during removal and / or transport, with a new valve box and / or lid at no additional cost to the City.

METER BOX REMOVAL:

Measurement for this item will be based on the number of **EACH** meter box removed.

The unit price bid for this item shall include the excavation, the intact and undamaged removal of the existing meter box, and safe transport and delivery of the meter box and lid to the Water Distribution Yard, where a receipt shall be obtained. Also included are dewatering, erosion and sediment control, tree protection, traffic control, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

The Contractor shall replace meter boxes and/or meter box lids that are damaged, or lost during removal and / or transport, with a new meter box and / or lid at no additional cost to the city.

TEST PITS:

Measurement for this item will be based on the number of **EACH** test pit performed.

Included in the unit cost of the test pits are all costs of locating buried utilities or structures by non-destructive, open cut methods (for the purpose of obtaining elevations) and where directed by the Engineer.

Costs included are excavation, bedding, backfill, compaction, dewatering, erosion and sediment control, traffic control, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching and permanent pavement replacement. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind, are also included items. All right of way restoration and related landscaping is also included. Any underground utilities, which are uncovered in the normal course of construction, will not be considered as test pits.

CURB/ CURB AND GUTTER REPLACEMENT:

Measurement for this item will be based on the number of **LINEAR FEET** installed when curb/curb and gutter is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional, in kind, curb/ curb and gutter work is to be performed within the project. All other pay items include the joint-to-joint replacement of curb / curb and gutter as part of their unit prices.

Included in the unit cost of curb/curb and gutter are all costs of stake out, providing and the accurate placement of concrete and / granite (in compliance with Public Works specifications), where directed by the Engineer. Without exception, all curb / curb and gutter will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work**.**

Costs included are excavation, bedding, form work installation and removal, erosion and sediment control, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration including associated adjacent paving and related landscaping is also included.

SIDEWALK REPLACEMENT:

Measurement for this item will be based on the number of **LINEAR FEET** of sidewalk installed when sidewalk is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional sidewalk work is to be performed within the project. All other pay items include the joint-to-joint replacement of sidewalk as part of their unit prices.

Included in the unit cost of sidewalk are all costs of providing and the accurate placement of concrete (in compliance with Public Works specifications), where directed by the Engineer. Without exception, all sidewalks will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work.

Costs included are stake out, excavation, bedding, form work, erosion and sediment control, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

DRIVEWAY REPLACEMENT:

Measurement for this item will be based on the number of **SQUARE YARDS** of driveway installed when driveway is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional, in kind**,** driveway work is to be performed within the project. All other pay items include the joint-to-joint replacement of driveway as part of their unit prices.

Included in the unit cost of driveway replacement (in compliance with Public Works specifications) are all costs of stake out, providing and the accurate placement of concrete, where directed by the Engineer. Without exception, all driveways will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work.

Costs included are excavation, bedding, form work, erosion and sediment control, driveway permits, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

DRIVEWAY APRON REPLACEMENT:

Measurement for this item will be based on the number of **EACH** driveway apron installed when driveway apron is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional driveway apron work is to be performed within the project. All other pay items include the joint-to-joint replacement of driveway aprons as part of their unit prices.

Included in the unit cost of driveway aprons are all costs of providing and the accurate placement of concrete (in accordance with Public Works specifications), where directed by the Engineer. Without exception, all driveway aprons will be replaced from joint to joint. NO EXCEPTIONS. At least one expansion joint will be placed in each section of replacement work.

Costs included are stake out, excavation, bedding, form work, erosion and sediment control, traffic control, driveway permits, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

TYPE I PAVEMENT RESTORATION:

Measurement for this item will be based on the number of **LINEAR FEET** of Type I Pavement installed. This pay item shall include all compensation for removing the existing pavement and providing and installing the required permanent pavement restoration above water mains as detailed in the Contract Drawings. Pavement restoration shall also include traffic control, tack coat and temporary and permanent thermoplastic pavement striping. All temporary pavement replacement shall be included in the cost of the item requiring it.

The pavement restoration sections shown on the Construction Drawings shall be considered a minimum. Where existing conditions exceed the minimum, the Contractor shall match the existing conditions. Removal of existing pavement and pavement replacement for the installation of service lines shall be included in the cost of that pay item.

TYPE II PAVEMENT RESTORATION:

Measurement for this item will be based on the number of **LINEAR FEET** of Type II Pavement installed. This pay item shall include all compensation for removing the existing pavement and providing and installing the required permanent pavement restoration above water mains as detailed in the Contract Drawings. Pavement restoration shall also include traffic control, tack coat, dowels (in accordance with Public Works specifications) and temporary and permanent thermoplastic pavement striping. All temporary pavement replacement shall be included in the cost of the item requiring it.

The pavement restoration sections shown on the Construction Drawings shall be considered a minimum. Where existing conditions exceed the minimum, the Contractor shall match the existing conditions. Removal of existing pavement and pavement replacement for the installation of service lines shall be included in the cost of that pay item.

TYPE III PAVEMENT RESTORATION:

Measurement for this item will be based on the number of **LINEAR FEET** of Type III Pavement installed. This pay item shall include all compensation for removing the existing pavement and providing and installing the required permanent pavement restoration (including dowels in accordance with Public Works specifications) above water mains as detailed in the Contract Drawings. Pavement restoration shall also include traffic control and temporary and permanent thermoplastic pavement striping. All temporary pavement replacement shall be included in the cost of the item requiring it.

The pavement restoration sections shown on the Construction Drawings shall be considered a minimum. Where existing conditions exceed the minimum, the Contractor shall match the existing conditions. Removal of existing pavement and pavement replacement for the installation of service lines shall be included in the cost of that pay item.

SANITARY SEWER ITEMS

SELECT BACKFILL:

Measurement for this item will be based upon the DAILY presentation of delivery tickets to the Inspector. **Delivery tickets must be given to the Inspector on a daily basis and will NOT be accepted with monthly invoices.** Select backfill will be measured and paid for by the **CUBIC YARD** at the established price of $15.00 per **CUBIC YARD**.
The Engineer shall approve select backfill such as borrow sand or other common granular fill hauled to the job site for use.

A delivery ticket shall accompany each load of select backfill material. Each ticket will be serially numbered, list the company supplying the fill material, truck number of trucks delivering material, date, size of load, and the project where delivered. In the event a material delivery ticket and delivery do not correspond, the Engineer may refuse the delivery and / or payment until such conditions are corrected to the satisfaction of the Engineer. Payment shall include the proper disposal of surplus material removed.

The Contractor shall designate the source of material and provide appropriate data as part of the submittal process. The Engineer shall approve select fill material hauled to the job site for use.

SELECT BEDDING, No. 57 STONE:

Measurement for this item, when properly installed will be based upon the DAILY presentation of delivery tickets to the Inspector. **Delivery tickets must be given to the Inspector on a daily basis and will NOT be accepted with monthly invoices.** Select bedding, No. 57 stone, will be measured and paid for by the **TON** at the established price of $18.00 per ton.

The Contractor shall designate the source of material and provide appropriate data as part of the submittal process. The Engineer shall approve select bedding material hauled to the job site for use.

Payment will only be made for special bedding used during the installation of pipe work and will not be paid for when in the opinion of the Engineer, proper dewatering methods have not been used. Special bedding required for the installation of manholes and where otherwise shown on the drawings will not be measured for payment as such, its' costs shall be included in the unit prices bid for those items.

A delivery ticket shall accompany each load of select bedding material. Each ticket will be serially numbered, list the company supplying the fill material, truck number of trucks delivering material, date, size of load, and the project where delivered. In the event a material delivery ticket and delivery do not correspond, the Engineer may refuse the delivery and / or payment until such conditions are corrected to the satisfaction of the Engineer. Payment shall include the proper disposal of surplus material removed.

SHEETING LEFT-IN-PLACE:
Timber sheeting as described in the drawings, specifications or as directed by the Engineer to be left in place, shall be measured for payment based upon total **THOUSAND BOARD FEET** of measure. Payment will be made at the unit price established under the "Schedule of Prices".

CLEAN AND TV SANITARY SEWER MAIN:
Measurement for this item shall be the actual distance measured in **LINEAR FEET** as measured horizontally along the centerline of the pipe from manhole to manhole, excluding manhole diameter.

Included in the unit cost for this pay item are all items necessary to perform the cleaning and videotaping of the existing sanitary sewer mains that are specified in these documents, shown on the contract drawings, or directed by the Engineer to be cleaned and video taped. This includes, but is not limited to cleaning, bypassing of sanitary sewer, video taping, providing a written log with the videotape, recording of information, permits, traffic control and the proper disposal of materials cleaned from the sewer mains in an approved manner.

Quantities shall not be exceeded without the PRIOR WRITTEN APPROVAL of the Engineer.

SANITARY SEWER MAIN INSTALLATION:
By size, pipe shall be measured horizontally in **LINEAR FEET** along the centerline of the main from manhole to manhole or from manhole to cleanout, excluding manhole diameter (s).

Included in the cost is furnishing and installing new sanitary sewer mains and wyes or other approved connectors, complete and in place. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, by-pass pumping or any other approved method to maintain existing sewer flow, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement and traffic control. Removal of existing pipe (where required), drop connections at existing drop manholes, reconnection of existing and active service laterals, dewatering, sheeting and / or shoring in accordance with OSHA regulations, clearing, grubbing, grading, boring or jacking, testing, backfilling and compaction, and post-installation TV inspection and video taping are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

The elevation of each newly installed sanitary sewer manhole shall be verified, in the presence of the Inspector, prior to continuing with the installation of the new sewer main. As part of the submittal process, the Contractor shall indicate what method is to be used to maintain line and grade on the proposed main.

SANITARY SEWER MAIN INSTALLATION (C-900):

By size, pipe shall be measured horizontally in **LINEAR FEET** along the centerline of the main from manhole to manhole or from manhole to cleanout, excluding manhole diameter (s).

Included in the cost is furnishing and installing new sanitary sewer mains (C-900 PVC) and wyes or other approved connectors, complete and in place. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, by-pass pumping or any other approved method to maintain existing sewer flow, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement and traffic control. Removal of existing pipe (where required), drop connections at existing drop manholes, reconnection of existing and active service laterals, dewatering, sheeting and / or shoring in accordance with OSHA regulations, clearing, grubbing, grading, boring or jacking, testing, backfilling and compaction, and post-installation TV inspection and video taping are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item. This item shall be used for sewer mains which are at a depth of 10’ or greater, or where determined by the engineer.

As part of the submittal process, the Contractor shall indicate what method is to be used to maintain line and grade on the proposed main.

SANITARY SEWER MAIN INSTALLATION (DUCTILE IRON):

By size, pipe shall be measured horizontally in **LINEAR FEET** along the centerline of the main from manhole to manhole or from manhole to cleanout, excluding manhole diameter (s).

Included in the cost is furnishing and installing new Ductile Iron sanitary sewer mains with Sewpercoat lining, and wyes or other approved connectors, complete and in place. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, by-pass pumping or any other approved method to maintain existing sewer flow, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement and traffic control. Removal of existing pipe (where required), drop connections at existing drop manholes, reconnection of existing and active service laterals, dewatering, sheeting and / or shoring in accordance with OSHA regulations, clearing, grubbing, grading, boring or jacking, testing, backfilling and compaction, and post-installation TV inspection and video taping are also included. The

removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

The elevation of each newly installed sanitary sewer manhole shall be verified, in the presence of the Inspector, prior to continuing with the installation of the new sewer main.

As part of the submittal process, the Contractor shall indicate what method is to be used to maintain line and grade on the proposed main.

SANITARY SEWER MAIN REHABILITATION:

By size, pipe shall be measured horizontally in **LINEAR FEET** along the centerline of the main from manhole to manhole or from manhole to cleanout, excluding manhole diameter (s).

Included are all costs of rehabilitating existing sanitary sewer mains and wyes or other approved connectors, complete and in place. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, by-pass pumping, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement, permanent pavement replacement and traffic control. Reconnection of existing and active laterals, drop connections at existing drop manholes, dewatering, clearing, grubbing, grading, testing, backfilling and compaction, and post-rehabilitation TV inspection and video taping are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

MANHOLE:

Measurement for this item will be based on the number of **EACH** manhole that is installed in the specified depth categories. The depth is measured from the lowest pipe invert to the rim of the manhole casting.

Included in the cost is furnishing and installing the required Norfolk standard pre-cast manhole, complete and in place. This cost shall include an adjustable / watertight manhole frame, dust cover, outside drops if needed, connections to the main line sewer and manhole lid. The removal of an existing manhole to install mains or manholes is included in this cost. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, stone bedding, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also

included items. All right of way restoration and related landscaping shall be incorporated in this item.

Note: When ordering a pre-cast manhole, an allowance should be made for at least one adjustment ring below the casting.

The elevation of each newly installed sanitary sewer manhole shall be verified, in the presence of the Inspector, prior to continuing with the installation of the new sewer main.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

ADJUSTABLE MANHOLE FRAME AND COVER:

Measurement for this item will be based on the number of **EACH** adjustable manhole frame (complete) installed.

The unit price bid for this item shall include all costs of the removal of the existing manhole casting and delivery to a location to be determined by the Engineer. Also included is the furnishing and installing a Norfolk standard adjustable manhole frame, dust cover and manhole lid set to grade, complete and in place. Additionally, dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction are included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

WATERTIGHT MANHOLE FRAME AND COVER:

Measurement for this item will be based on the number of **EACH** watertight manhole frame (complete) installed.

The unit price bid for this item shall include all costs of the removal of the existing manhole casting, furnishing and installing a Norfolk standard watertight manhole frame, dust cover and manhole lid set to grade, complete and in place. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

MANHOLE REHABILITATION:
Measurement for this item will be based on the number of **EACH** manhole rehabilitated.

The unit price bid for this item shall include all costs of the cleaning, repairing and sealing of all manhole surfaces, including walls, inverts and benches in an approved manner, complete and in place. The application of liner materials, testing, by-pass pumping, traffic control and all other work needed to fully rehabilitate the manhole is included in this cost. Also included in the price is the uncovering of the manhole if paved over.

DUST COVER:
Measurement for this item will be based on the number of **EACH** dust cover that is installed.

This pay item shall include all costs of furnishing and installing dust covers in manholes where there is no dust cover, or where the existing dust cover is deteriorated and / or where directed by the Engineer to be replaced.

MAIN LINE CLEANOUT:
Measurement for this item will be based on the number of **EACH** main line cleanout that is installed.

Included in the cost is furnishing and installing the required Norfolk standard main line cleanout, complete and in place. This cost shall include connection to the end of the main line sewer with approved fittings, frame and lid. The removal of the existing main line cleanout is included in this cost. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

POINT REPAIR:

A point repair is a repair made to an existing sanitary sewer main prior to the rehabilitation of that main. Point repairs are determined to be necessary based on information obtained from videotape inspection. **All point repairs greater than 20 feet in length will be compensated for under the pay item for sanitary sewer replacement based upon linear feet and will NOT be compensated for under this pay item.**

Measurement for this item will be based on the number of **EACH** point repair made that was 20 feet or less in length.

Included are all costs of connecting to the existing sanitary sewer mains, furnishing and installing new pipe and fittings, complete and in place. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, by-pass pumping or any other approved method to maintain existing sewer flow, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement, permanent pavement replacement and traffic control. Reconnection of existing and active laterals, drop connections at existing drop manholes, dewatering, sheeting and / or shoring in accordance with OSHA regulations, boring or jacking, testing, backfilling and compaction, and post-rehabilitation TV inspection and video taping are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

HUBBED-IN LATERAL REMOVAL:

Measurement for this pay item shall be for the number of **EACH** hubbed-in lateral removed, as determined by the Engineer. Removal shall be performed by the internal remote control removal methods. This pay item is full compensation for the complete hub removal process.

SERVICE LATERAL REPLACEMENT (PUBLIC):

Pipe shall be measured horizontally along the centerline of the lateral from the centerline of the sewer main (inside edge of manhole for laterals connected to manholes) to the newly installed property line clean out, or to the point of connection to the existing lateral. Lateral pipe shall be measured based on the **LINEAR FEET** of pipe installed, complete and in place.

Included in the cost is furnishing and installing the service lateral lines located within the City's right of way. This cost shall include the locating of, and connection to, existing service lateral at new or existing manhole, or main, including approved saddles or fittings. Also included are erosion and sediment control, tree protection, traffic control, excavation, clearing, grubbing, grading, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement patching and permanent pavement replacement. Dewatering, sheeting and / or shoring in accordance

with OSHA regulations, clearing, grubbing, grading, boring or jacking, backfilling and compaction are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

SERVICE LATERAL REPLACEMENT – DUCTILE IRON (PUBLIC):

Pipe shall be measured horizontally along the centerline of the lateral from the centerline of the sewer main (inside edge of manhole for laterals connected to manholes) to the newly installed property line clean out, or to the point of connection to the existing lateral. Lateral pipe shall be measured based on the **LINEAR FEET** of pipe installed, complete and in place.

Included in the cost is furnishing and installing the ductile iron (with SEWPERCOAT) service lateral lines located within the City's right of way. This cost shall include the locating of, and connection to, existing service lateral at new or existing manhole, or main, including approved saddles or fittings. Also included are erosion and sediment control, tree protection, traffic control, excavation, clearing, grubbing, grading, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement patching and permanent pavement replacement. Dewatering, sheeting and shoring in accordance with OSHA regulations, clearing, grubbing, grading, boring or jacking, backfilling and compaction are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

PROPERTY LINE CLEANOUT:

Measurement for this item will be based on the number of **EACH** property line cleanout that is installed.

Included in the cost is furnishing and installing the required Norfolk standard property line cleanout, complete and in place. This cost shall include connection to the service lateral with approved fittings, frames and lids. The removal of existing property line cleanouts are included in this cost if the property line cleanout being removed is in the same excavation as the newly installed service lateral and / or private cleanout. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, care and protection of existing utilities and structures, dewatering, clearing,

grubbing, grading, boring or jacking, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

SERVICE LATERAL REPLACEMENT (PRIVATE):

Pipe shall be measured horizontally along the centerline of the lateral from the centerline of the newly installed property line clean out to the point of connection to the existing lateral, or to within five feet of the building or house. Lateral pipe shall be measured based on the **LINEAR FEET** of pipe installed, complete and in place.

Included in the cost is furnishing and installing the service lateral lines located on private property. This cost shall include the locating of, and connection to, the existing service or new lateral with approved fittings and the abandonment or removal of the existing lateral. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement patching, permanent pavement replacement and traffic control. Dewatering, clearing, grubbing, grading, boring or jacking, backfilling and compaction are also included. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

A licensed plumbing contractor shall perform all plumbing work.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

PRIVATE PROPERTY CLEANOUT:

Measurement for this item will be based on the number of **EACH** private property cleanout that is installed.

Included in the cost is furnishing and installing the required private property lateral cleanout, complete and in place. These private cleanouts will be placed at the house, at bends or at any change in direction or as directed by the Plumbing Inspector, in conjunction with the replacement of service laterals on private property. This cost shall include connection to the service lateral with approved fittings, frames and lids. The removal of existing private property cleanouts are included in this cost if the private property cleanout being removed is in the same excavation as the newly installed private

lateral and / or private cleanout. Also included are erosion and sediment control, tree protection, excavation, clearing, grubbing, grading, care and protection of existing utilities and structures, dewatering, grading, boring or jacking, backfilling and compaction. The removal, proper disposal and complete joint to joint in kind replacement of private walkways, steps, stoops and driveways are also included items. All restoration and related landscaping shall be incorporated in this item.

Private property cleanouts are to be installed in accordance with the BOCA National Plumbing Code by a licensed plumbing contractor.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

PLUMBING TURNAROUND:

Measurement for this item will be based on the number of **EACH** Plumbing turnaround that is performed.

Included in the costs for this pay item are all materials and labor (complete and in place) to turn around the direction of the existing sanitary sewer lateral underneath the house and to extend the piping through the foundation wall to five feet past the outside wall of the house. This pay item includes any and all repairs to foundation walls.

Plumbing turnarounds are to be installed in accordance with the BOCA National Plumbing Code by a licensed plumbing contractor

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

PLUMBING REPAIR ALLOWANCE:

Measurement for this item will be based on the **ACTUAL COST** of the minor plumbing repair work on private property.

This pay item shall be full reimbursement for minor plumbing repair work on service lines on private property. Payment under this item shall be made only when the defect is determined to be “pre-existing” and the Engineer has authorized the repair work in writing prior to execution of the repair work. All necessary landscape restoration shall be included.

No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

PLUMBING PERMIT ALLOWANCE:

Measurement for this item will be based on the number of **EACH** plumbing permit obtained. (The amount of $40.65 is established as the cost of the permit ($35.35) plus 15% for overhead and profit.)

This pay item shall be full reimbursement for all obtained plumbing permits for the replacement of sewer service lines on private property. The Contractor shall be reimbursed for the actual number of permits obtained as evidenced by the receipts submitted to and approved by the Engineer. Receipts shall be submitted with monthly invoices.

FLOWABLE FILL:

Measurement for this item is **CUBIC YARDS** as determined by delivery tickets received at the job site on a daily basis. This pay item shall include costs for plugging pipe (s), furnishing and placing flowable fill material in pipes to be abandoned in the manner described in the specifications, shown on the Construction drawings or as directed by the Engineer. Included in the costs is excavation, backfilling, pavement removal and proper disposal, temporary and permanent pavement replacement, concrete and/or granite curb / curb and gutter, valley gutter, sidewalk, driveway, and driveway apron replacement in kind, area restoration and any other cost not included in any other pay item.

MANHOLE REMOVAL:

Measurement for this item will be based on the number of **EACH** manhole that is removed.

As part of the abandonment process, portions of the existing sanitary sewer system will be separated from the new sanitary sewer system. Sewer mains will be plugged with a brick and mortar plug, manholes and cleanouts will be removed, demolished or filled with flowable fill, sewer mains will be removed or filled with flowable fill, and existing property line cleanouts will be removed from the soil or from the concrete. This pay item is full compensation for the abandonment of manholes.

The manhole removal pay item shall include the removal of the casting and lid and the top 3 feet (minimum) of the manhole. Also included is the plugging of the manhole openings and filling the remainder of the manhole with flowable fill or select backfill, compaction and complete restoration of the area to its' original condition. This pay item includes safe transport and delivery of the manhole casting and lid to the Wastewater office. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way

restoration and related landscaping shall be incorporated in this item. No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

The Contractor shall replace manhole castings, dust covers and / or lids damaged during removal and / or transport, with a new casting, dust cover and / or lid at no additional cost to the City.

MAIN LINE CLEANOUT REMOVAL:

Measurement for this item will be based on the number of **EACH** main line cleanout that is removed.

As part of the abandonment process, portions of the existing sanitary sewer system will be separated from the new sanitary sewer system. Sewer mains will be plugged with a brick and mortar plug, manholes and cleanouts will be removed, demolished or filled with flowable fill**,** sewer mains will be removed or filled with flowable fill, and existing property line cleanouts will be removed from the soil or from the concrete. This pay item is full compensation for the abandonment (removal) of main line cleanouts. Cleanouts removed to install new manholes are included in the price of the manhole.

The main line cleanout removal shall include the removal of the existing main line cleanout and lid, removal of 18" of riser pipe (minimum), plugging the open end of the riser, filling with flowable fill, safe transport and delivery of the cleanout casting and lid to the Wastewater office. Also included are dewatering, backfill, compaction, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item. No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

The Contractor shall replace cleanouts and / or lids damaged during removal and / or transport, with a new cleanout and / or lid at no additional cost to the City.

CLEANOUT REMOVAL IN CONCRETE:

Measurement for this item will be based on the number of **EACH** property line cleanout in concrete that is removed.

As part of the abandonment process, portions of the existing sanitary sewer system will be separated from the new sanitary sewer system. Sewer mains will be plugged with a brick and mortar plug, manholes and cleanouts will be removed, demolished or filled with flowable fill, sewer mains will be removed or filled with flowable fill, and existing property line cleanouts will be removed from the soil or from the concrete. This pay item is full compensation for the cleanout abandonment in concrete.

The cleanout removal in concrete shall include the removal of the existing cleanout and lid, removal of 18" of riser pipe (minimum), plugging the open end of the riser, filling with flowable fill, safe transport and delivery of the cleanout casting and lid to the Wastewater office, backfill and compaction. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with OSHA regulations, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching, permanent pavement replacement, backfilling and compaction. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item. No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

There shall be no compensation for cleanouts that are removed in the course of installation of a new and / or replacement service lateral. The cost of such removal, the in kind concrete replacement, and casting and lid delivery, shall be included in the cost of the installation of the service lateral.

The Contractor shall replace cleanouts and / or lids damaged during removal and / or transport, with a new cleanout and / or lid at no additional cost to the City.

CLEANOUT REMOVAL IN SOIL:

Measurement for this item will be based on the number of **EACH** property line cleanout in soil that is removed.

As part of the abandonment process, portions of the existing sanitary sewer system will be separated from the new sanitary sewer system. Sewer mains will be plugged with a brick and mortar plug, manholes and cleanouts will be removed, demolished or filled with flowable fill, sewer mains will be removed or filled with flowable fill, and existing property line cleanouts will be removed from the soil or from the concrete. This pay item is full compensation for the cleanout abandonment in soil.

The cleanout removal in soil shall include the removal of the existing cleanout and lid, removal of 18" of riser pipe (minimum), plugging the open end of the riser with mortar, safe transport and delivery of the cleanout casting and lid to the Wastewater office, backfill and compaction. Also included are dewatering, erosion and sediment control, tree protection, traffic control, excavation, sheeting and/or shoring in accordance with

OSHA regulations, clearing, grubbing, grading, care and protection of existing utilities and structures, backfilling and compaction. All right of way restoration and related landscaping shall be incorporated in this item. No payment request shall be made for this item until all landscape restoration work is complete to the satisfaction of the Engineer.

There shall be no compensation for cleanouts that are removed in the course of installation of a new and / or replacement service lateral. The cost of such removal and the safe delivery of the casting and lid shall be included in the cost of the installation of the service lateral.

The Contractor shall replace cleanouts and / or lids damaged during removal and / or transport, with a new cleanout and / or lid at no additional cost to the City.

TEST PITS:

Measurement for this item will be based on the number of **EACH** test pit performed.

Included in the unit cost of the test pits are all costs of locating buried utilities or structures by non-destructive methods as directed by the Engineer.
Costs included are excavation, bedding, backfill, compaction, dewatering, erosion and sediment control, traffic control, pavement removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures, temporary pavement patching and permanent pavement replacement. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk and driveway, driveway apron, in kind, are also included items. All right of way restoration and related landscaping is also included. Any existing utilities, which are uncovered in the normal course of the work, shall not be considered as test pits.

CURB/ CURB AND GUTTER REPLACMENT:

Measurement for this item will be based on the number of **LINEAR FEET** installed when curb /curb and gutter is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional, in kind, curb/ curb and gutter work is to be performed within the project. All other pay items include the joint-to-joint replacement of curb / curb and gutter as part of their unit prices.

Included in the unit cost of curb/curb and gutter are all costs of providing and the accurate placement of concrete and/or granite, (in compliance with public works specifications), where directed by the Engineer. Without exception, all curb / curb and gutter will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work.

Costs included are excavation, bedding, form work, erosion and sediment control, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

SIDEWALK REPLACMENT:

Measurement for this item will be based on the number of **LINEAR FEET** of sidewalk installed when sidewalk is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional, in kind; sidewalk work is to be performed within the project. All other pay items include the joint-to-joint replacement of sidewalk as part of their unit prices.

Included in the unit cost of sidewalk are all costs of providing and the accurate placement of concrete, (in compliance with public works specifications), where directed by the Engineer. Without exception, all sidewalks will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work.

Costs included are excavation, bedding, form work, erosion and sediment control, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

DRIVEWAY REPLACMENT:

Measurement for this item will be based on the number of **SQUARE YARDS** of driveway installed when driveway is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional, in kind; driveway work is to be performed within the project. All other pay items include the joint-to-joint replacement of driveway as part of their unit prices.

Included in the unit cost of sidewalk are all costs of providing and the accurate placement of concrete, (in compliance with public works specifications), where directed by the Engineer. Without exception, all driveways will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work.

Costs included are excavation, bedding, form work, erosion and sediment control, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

DRIVEWAY APRON REPLACEMENT:
Measurement for this item will be based on the number of **EACH** driveway apron installed when driveway apron is not included as part of the work contained under another line item.

The intent of this pay item is to provide compensation when additional, in kind; driveway work is to be performed within the project. All other pay items include the joint-to-joint replacement of driveway aprons as part of their unit prices.

Included in the unit cost of driveway aprons are all costs of providing and the accurate placement of concrete, (in compliance with public works specifications), where directed by the Engineer. Without exception, all driveway aprons will be replaced from joint to joint. At least one expansion joint will be placed in each section of replacement work.

Costs included are excavation, bedding, form work, erosion and sediment control, traffic control, concrete removal and proper disposal, clearing, grubbing, grading, care and protection of existing utilities and structures. All right of way restoration and related landscaping is also included.

TYPE I PAVEMENT RESTORATION:
Measurement for this item will be based on the number of **LINEAR FEET** of Type I Pavement installed. This pay item shall include all compensation for removing and proper disposal of the existing pavement and providing and installing the required permanent pavement restoration above sewer mains as detailed in the Contract Drawings. Pavement restoration shall also include traffic controls, tack coat and temporary and permanent thermoplastic pavement striping. All temporary pavement replacement shall be included in the cost of the item requiring it.

The pavement restoration sections shown on the Construction Drawings shall be considered a minimum. Where existing conditions exceed the minimum, the Contractor shall match the existing conditions. Removal of existing pavement and pavement replacement for the installation of service lines shall be included in the cost of that pay item.

TYPE II PAVEMENT RESTORATION:
Measurement for this item will be based on the number of **LINEAR FEET** of Type II Pavement installed. This pay item shall include all compensation for removing and the proper disposal of the existing pavement and providing and installing the required permanent pavement restoration above sewer mains as detailed in the Contract Drawings. Pavement restoration shall also include traffic controls, dowels (in accordance with Public Works specifications), tack coat and temporary and permanent thermoplastic pavement striping. All temporary pavement replacement shall be included in the cost of the item requiring it.

The pavement restoration sections shown on the Construction Drawings shall be considered a minimum. Where existing conditions exceed the minimum, the Contractor shall match the existing conditions. Removal of existing pavement and pavement replacement for the installation of service lines shall be included in the cost of that pay item.

TYPE III PAVEMENT RESTORATION:

Measurement for this item will be based on the number of **LINEAR FEET** of Type III Pavement installed. This pay item shall include all compensation for removing and proper disposal of the existing pavement and providing and installing the required permanent pavement restoration above sewer mains as detailed in the Contract Drawings. Pavement restoration shall also include traffic controls, dowels (in accordance with Public Works specifications) and temporary and permanent thermoplastic pavement striping. All temporary pavement replacement shall be included in the cost of the item requiring it.

The pavement restoration sections shown on the Construction Drawings shall be considered a minimum. Where existing conditions exceed the minimum, the Contractor shall match the existing conditions. Removal of existing pavement and pavement replacement for the installation of service lines shall be included in the cost of that pay item.

MISCELLANEOUS

NEOPRENE RUBBER PADS:

Measurement for this item will be based on the number of **EACH** neoprene rubber pad that is installed.

This pay item shall be full reimbursement for furnishing and installing a 6" X 6" X 6" neoprene rubber pad complete and in place. These pads are to be installed where indicated on the Contract drawings or at the direction of the Engineer.

TROLLEY TRACKS FOUNDATION REMOVAL:

Measurement for this item shall be based upon the **LINEAR FEET** (parallel to the track) of trolley tracks foundation removed that are 18" or greater in thickness. (The costs associated with the removal of any foundation that is less than 18" thick shall be included in the cost of pipe installed.) Included in the costs are all excavation, track and foundation removal and proper disposal and backfilling. Also included are erosion and sediment control, tree protection, clearing, grubbing, grading, care and protection of existing utilities and structures, pavement removal and proper disposal, temporary pavement, permanent pavement replacement and traffic control. The removal, proper disposal and complete joint-to-joint replacement of: granite and concrete curb, curb and gutter, valley gutter, sidewalk, driveway and driveway apron, in kind are also included items. All right of way restoration and related landscaping shall be incorporated in this item.

PAVEMENT MILLING:

Measurement for this item shall be for each **SQUARE YARD** of asphalt concrete pavement milled. Pavement shall be milled as shown on the Contract Drawings, described in the Specifications, or as directed by the Engineer.

6" AGGREGATE BASE:

Measurement for this item shall be for each **SQUARE YARD** of aggregate base material placed. The costs shall include the furnishing and placement of a minimum of 6" aggregate base material, or as directed by the Engineer, in conformance with lines, grades and thickness shown on the Construction drawings. Included shall be the cost of sub-grade preparation including excavation, grading and sub-grade compaction as specified.

ASPHALT BASE COURSE, B-3:

Measurement for this item shall be for each **TON** that is placed as specified. Included in the costs shall be the furnishing and placement of the asphalt base course B-3 material in conformance to lines, grades and thickness shown on the Construction drawings, as directed by the Engineer, or as described in the specifications. Tack coat is included in the cost of this item

ASPHALT SURFACE COURSE, S-5:

Measurement for this item shall be for each **TON** that is placed as specified. Included in the costs shall be the furnishing and placement of the asphalt surface course S-5 material in conformance to lines, grades and thickness shown on the Construction drawings, as directed by the Engineer, or as described in the specifications. Tack coat is included in the cost of this item.